A SYSTEMATIC REVISION OF *ZYGOPHYLLUM* (ZYGOPHYLLACEAE) IN THE SOUTHERN AFRICAN REGION

by

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Declaration

I, the undersigned, hereby declare that the work contained in this dissertation is my own original work and has not previously, in its entirety or in part, been submitted at any university for a degree.

UITTREKSEL

Die vorige hersiening van *Zygophyllum* L., deur Van Huyssteen (1937), het alle bekende spesies van die kosmopolitaanse genus *Zygophyllum* ingesluit. Die huidige studie handel slegs oor die Suider afrikaanse *Zygophyllum*-spesies wat in Angola, Namibië, Botswana en Suid-Afrika voorkom. Die meerderheid *Zygophyllum* spesies groei in ariede en semi-ariede dele aan die weskus asook in die binneland van die area maar sommige spesies groei ook in die suide van die gebied met 'n meer gematigde klimaat. *Zygophyllum*-spesies word beskryf as struike of halfstuike, is selde kruidagtige, een- of tweejariges en het gewoonlik eenvoudige, sittende blare of sittende verdeelde of gesteelde verdeelde, sukkulente blare.

Makromorfologiese en geografiese data is bestudeer om die verskillende taxa af te baken, om verwantskappe tussen die onderskeie spesies vas te stel sowel as om die verspreiding vir elke takson aan te gee. Tabelle met die vernaamste taksonomies kenmerke asook lynsketse van die mees belangrike kenmerke van die verskillende species word verskaf.

Die verdeling van *Zygophyllum* in twee subgenera is ondersoek en is, met behulp van bykomende blom-, vrug- en saadmorfologiese inligting, volkome regverdig bevind. Die aan- of afwesigheid van elaiosome op sade dui op verskillende saadverspreidings metodes. Die morfologies-verskillende slymlaag wat deur die saad van die twee subgenera produseer word, is kortliks beskryf. Die verdeling van die subgenera *Agrophyllum* en *Zygophyllum* in verskeie seksies is ondersoek. Die monotipiese subseksie *Morgsana* word na subgenus *Zygophyllum* en die monotipiese § *Grandifolia* na subgenus *Agrophyllum* verskuif. Die § *Prismatica* word as nuut beskryf en die § *Annua* word in hergebruik geneem. Sestien nuwe spesies word beskryf, enkele name word in sinonimie geplaas.

ABSTRACT

The previous revision of *Zygophyllum* L. by Van Huyssteen (1937) included all known species of the cosmopolitan genus *Zygophyllum*. The present study deals with the species of *Zygophyllum* occurring in the southern African region which includes Angola, Namibia, Botswana and South Africa. The majority of *Zygophyllum* species occur in the arid and semi-arid, western parts as well as in the interior parts but some species do occur to the south of the area where milder climatic conditions are experienced. *Zygophyllum* species are typically described as shrubs or shrublets, rarely herbaceous annuals or biennials, with simple, sessile leaves or sessile, bifoliolate or petiolate, bifoliolate leaves of a succulent texture.

Macromorphological as well as phytogeographical data were studied in order to delimit the taxa and to determine their relationships as well as their distributions. Various tables summarizing diagnostic characters of taxonomic importance as well as line drawings depicting the salient features of the species are given.

The division of the genus *Zygophyllum* into two subgenera was investigated and this division is corroborated with additional evidence concerning floral, fruit and seed morphology. The absence or presence of an elaiosome on the seeds found in the two subgenera reflects on their different dispersal strategies. The structure of the morphologically different mucilage produced by the seeds of the two subgenera is touched on. The division of the subgenera *Agrophyllum* (Neck.) Endl. and *Zygophyllum,* each into several sections, was investigated. Two sections, one from each subgenus, were transferred: the monotypic § *Morgsana* (Huysst.) Van Zyl to subgenus *Zygophyllum*; and the monotypic § *Grandifolia* Engl. to subgenus *Agrophyllum*. The § *Prismatica* Van Zyl is newly described and the § *Annua* Engl. is reinstated. seventeen new species are described, a few names sunk into synonymy and several name changes made.

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CONTENTS

CHAPTER 1

INTRODUCTION

Zygophyllaceae

The Zygophyllaceae is a widespread, heterogeneous family of ca. 30 genera and 250 species, adapted to the arid, semi-arid and saline areas throughout the tropics and subtropics (Zohary 1973, Cronquist 1981). Dyer (1975) and El Hadidi (1985) describe the *Zygophyllaceae* as perennial herbs, shrubs or rarely trees, usually with opposite, simple, petiolate, bifoliolate or pinnate leaves and entire leaflets that are flat or fleshy or sometimes terete, stipulate; flowers usually solitary or occasionally in cymes, mostly bisexual, regular or rarely zygomorphic; calyx and petals usually free, (3-)5; stamens usually twice as many as petals, in 1—2 whorls, hypogynous and filaments free, usually terete, often with appendages at base; ovary superior, on a annular disc, furrowed, angled or winged, usually 3–5-locular, with axile placentation; 2—many pendulous ovules in each locule; style usually simple; stigma simple; fruit a loculicidal capsule or a schizocarp dividing septicidally in mericarps which can be winged, tuberculate or spinescent or rarely a berry or drupe; seeds with or without endosperm, mucus producing or not; embryo straight or slightly curved.

The first to recognize *Zygophyllaceae* as a distinct taxon under the name Zygophylleae was R. Brown in 1814, followed by authors like De Candolle (1824), Endlicher (1841), Lindley (1853) and Bentham & Hooker (1862). After this initial period, additional information was accommodated in several revisions of the Zygophyllaceae produced for specific geographical areas, e.g. Flora Capensis (Sonder 1860), Flora Australiensis (Bentham & F. Mueller 1863), Flora Orientalis.....(Boissier 1867), Plantae lorentzianae (Grisebach 1874) and Symbolae ad floram argentinam (Grisebach 1879) and North American Flora (Vail & Rydberg 1910).

A comprehensive treatment of the *Zygophyllaceae* was produced by Engler (1896, 1931). He divided the family of ca. 25 genera into seven subfamilies: *Tetradiclidoideae, Augeoideae, Zygophylloideae, Peganoideae, Chitonioideae,*

Nitrariodeae and *Balanitoideae*. Engler's *Zygophylloideae*, including *Zygophyllum*, is the largest subfamily (17 of the 25 genera) and forms a central, typical taxon within the family (El Hadidi 1975). However, the systematic relationships within the family is the topic of an ongoing debate and have led to numerous investigations of the morphology, palynology, cytology and biochemistry of the family, the results of which confirm the morphological diversity of the family (Sheahan & Cutler 1993). A chronological list of taxonomic treatments of *Zygophyllaceae* by various authors, as well as a suggested recircumscription of *Zygophyllaceae* to comprise five subfamilies only, is given by Sheahan & Chase (1996).

Engler (1931) divided the subfamily Zygophylloideae into two tribes, Zygophylleae (including *Zygophyllum*) and Tribuleae. The latter tribe is treated as a distinct family by El Hadidi (1977). Engler (1931) further divided Zygophylleae into two subtribes, Fagoniinae and Zygophyllinae (10 genera including *Zygophyllum*). Engler (1931) considered Zygophyllinae to be shrubs, herbs or small trees with simple or pinnate leaves, flowers sessile or peduncled and stamens with or rarely without staminal scales. He considered the genus *Zygophyllum* to consist of herbs or shrubs mostly with thick, fleshy leaves and occurring in the deserts or semi-deserts of the Old World. Engler (1931) divided *Zygophyllum* into 17 different sections. Thirteen of these sections were newly described by Engler, whereas he used previously described generic names for four of his sections, e.g. *Roeperia* A. Juss., *Sarcozygium* Bunge, *Milianthus* Bunge and *Halimiphyllum* A. Boriss. These last mentioned sections deal with *Zygophyllum* species outside the southern African region.

Zygophyllum **L.**

Dyer (1975) and El Hadidi (1985) described the genus as shrublets or shrubs, rarely herbaceous annuals; leaves opposite, simple or bifoliolate, sessile or petiolate, leaflets often fleshy and variable in shape, stipulate; flowers solitary or rarely cymous; sepals 3–5; disc fleshy, angled or lobed; stamens twice as many as petals, inserted at base of disc; filaments terete, with an entire, bifid or 2-partite appendage; ovary usually sessile on the disc, lobed, angled or globose, 3—5-locular, ovules few to many in each locule; style terete; stigma usually simple; fruit

a lobed, angled or winged capsule or schizocarp; seeds with or without endosperm, usually mucous producing; embryo usually straight.

The genus *Zygophyllum* is the largest genus of the family but with an uncertainty about the exact number of species. Dyer (1975) mentioned about 100 *Zygophyllum* species in Africa and Australia and El Hadidi (1975) reduced the number to about 80 species from Africa, Australia as well as Asia. According to him only three species are extending into the Mediterranean region. According to Index Kewensis ca. 130 species of *Zygophyllum* are recognized of which ca. 70 species occur in north-east Africa, the Middle Eastern Countries and Asia, ca. 22 species in Australia and ca. 35 species in south-west Africa. As a result of this study 17 new species can be added to the south-west African region, bringing the total number of *Zygophyllum* species to ca 150.

Zygophyllum of the south-west African region

This study deals with *Zygophyllum* species of the south-west African region, except for the two widespread species, *Z. simplex* L. and *Z. decumbens* Del. var. *decumbens,* which occur in the north-African and Asian regions as well and which are included in this study.

Engler's (1931) comprehensive treatment included all known *Zygophyllum* species at the time and divided *Zygophyllum* into 17 sections, using four previously described generic names and 13 other names described by himself. Unfortunately there was no proper basis for constructing these sections and according to current thought the sections were compilations of heteromorphic elements. Engler (1931) failed to implement the most competent subdivision of Endlicher (1841), based on the dehiscence of the fruit.

Sonder (1860) provided a classification for the 25 South African species known at the time. Although quoting Endlicher (1841), he also failed to use Endlicher's accurate division of *Zygophyllum* into two groups: a. *Fabago* - with loculicidal fruits and an adnate raphe; b. *Agrophyllum* - with septicidal fruits and a free raphe. Sonder (1860) concentrated mainly on leaf characters which he used in combination with floral characters for his subdivisions and failed to group species according to their natural affinities. He grouped *Z. cordifolium* together with Z. *prismatocarpum*

and *Z. simplex* because of their similar, simple leaves but currently these three species are regarded as similar with respect to their leaf characters only, but not with regard to their floral characters. According to floral characters they are placed into different subgenera.

Van Huyssteen's (1937) classification dealt with all *Zygophyllum* species known at the time with special reference to the African species. In contrast to Sonder (1860), she recognized the taxonomic importance of floral and fruit characters and accepted Endlicher's (1841) subdivision of the genus based on fruit dehiscence, whereas she considered the habit and leaf characters as of limited taxonomic importance. Van Huyssteen (1937) reorganised many of Engler's 17 sections and at the same time described several additional new sections.

The southern African *Zygophyllum* species as arranged by Van Huyssteen (1937), with author citations:

A. Subgenus *Agrophyllum* Endl.
   1. Section *Bipartita* Huysst. (10 species)
   3. Section *Cinerea* Huysst. (I species)
   4. Section *Alata* Huysst.
      Subsection (1) *Angustialata* Huysst. (6 species)
      Subsection (2) *Morgsana* Huysst. (I species)

B. Subgenus *Zygophyllotypus* Huysst.
   5. Section *Paradoxa* Huysst.(3 species)
   6. Section *Grandifolia* Engl. (I species)
   7. Section *Capensia* Engl. (24 species)

She listed some insufficiently understood species at the end.

Van Huyssteen's classification provides a good basis for subsequent arrangements of *Zygophyllum* species. However, her work is inadequate in some aspects. With the exception of the six new species described by her, she provided no descriptions for the 95 *Zygophyllum* species listed by her and gave inadequate nomenclatural references by referring to basionyms only. Only one key was provided dealing with

all taxa, no matter their geographical distribution. This is quite impractical. She also did no field work which in my opinion is essential for understanding *Zygophyllum.*

Schreiber (1963) dealt with the 18 *Zygophyllum* species known from Namibia at the time. Her work included the typification of names, taxonomic nomenclature and distribution maps of all species listed. However, like Van Huyssteen, she did no field work and provided no descriptions for the *Zygophyllum* species which she listed in alphabetical order and without cognizance of their affinities.

The discussion of the previous works relating to *Zygophyllum* in the south-west African region reveals some shortcomings. Some of the reports on *Zygophyllum* showed a lack of data on mature fruits, e.g. Engler (1896, p14), Van Huyssteen (1937, p 73 & 75). The aim of the present study was to try to rectify the shortcomings mentioned, to obtain representative and adequate specimens of all taxa, to produce an adequate revision according to modern standards, including proper species descriptions and distribution maps and to construct keys to identify the different sections as well as the species.

CHAPTER 2

MATERIAL AND METHODS

This study was mainly based on macromorphological characters and distribution patterns of the different species.

Zygophyllum L. is a cosmopolitan genus occurring on several continents. This study deals with *Zygophyllum* taxa occurring in southern Africa only. Two of the taxa, *Z. simplex* L. and *Z. decumbens* Del. var. *decumbens* included in this study, have wider distributions occurring both in southwest Africa and in northeast Africa and Asia. When *Zygophyllum* is mentioned in this study it refers to the southern African species only.

All available literature since 1753, and in some cases literature preceding that date, was studied for relevant names and synonyms of *Zygophyllum*.

Herbarium specimens, obtained from the larger southern African herbaria, BOL, GRA, NBG, PRE and NAM (abbreviations according to Holmgren et al., 1981), were studied. A search for type material followed and some of the important herbaria in Europe, concerning *Zygophyllum,* were visited and their names are given in alphabetical order: B, BM, C, K, LINN, P, S, UPS, Z. As several types could not be found during this visit, the search for type material is continuing.

As most *Zygophyllum* species are drought-deciduous leaf succulents, many of the herbarium specimens are in a poor condition because of the loss of some vegetative and floral parts. A considerable number of specimens were completely leafless and without any flowers or fruits at all. Thus, no conclusions could be drawn about the status of the different taxa before a proper study of the species in their natural environment had been done. With the help of preliminary distribution maps drawn from the herbarium specimens, extensive field work was done over a period of eleven years. Flowering specimens as well as material with mature and immature fruits were only obtained after several visits during different seasons to known

localities. The succulent nature of the fruits of many *Zygophyllum* species causes a delay in their drying, which meant additional journeys to get properly matured and dried fruits. About 1000 specimens were collected and prepared as herbarium specimens were made. Of some specimens colour photographs of the habit of plants in their natural habitat were taken and of some specimens vegetative, floral and fruit material was preserved in FAA (formaline-alcohol-acetic acid fixative). The field study covered all known species with three exceptions, *Z. divaricatum* Eckl. & Zeyh. occurring in the Eastern Cape, *Z. orbiculatum* Welw. ex Oliver from Angola and *Z. inflatum* Van Zyl from Namibia and Angola. Duplicates of the herbarium specimens will be distributed to the various herbaria. Several additional trips were made to obtain fresh, flowering and fruiting material for illustrations of the new species. Depending on the availability of material, at least five but in most cases more specimens, covering the distribution range of a taxon, were analyzed to obtain the macromorphological data. The descriptive terminology used in this study is based on that of Radford *et al.* (1974).

The taxonomic treatment is arranged according to the guide for contributors to the *South African Journal of Botany* which includes the format for references to the literature and specimens cited. Nomen nudum are given. Author names of taxa appear in the contents, Chapter 6 and Appendix.

The data on the geographical distribution of all herbarium specimens cited, were computerized, using the PC-File+ database programme. Geographical distribution of the specimens was cited according to the grid reference method proposed by Leistner & Morris (1976). A distribution map for every taxon was compiled from these data. Additional ecological data for each taxon were obtained by plotting each taxon on vegetation maps according to Irish (1994) and Low & Rebelo (1996).

Leaf anatomical studies on most of the *Zygophyllum* taxa were performed by Kuun (1997) and quoted where relevant to this study. Preserved material used for anatomical studies, are based on own collections.

CHAPTER 3

MORPHOLOGICAL CHARACTERS AND TAXONOMIC CRITERIA

The fallacies of relying on single characters or those of a purely vegetative nature in classification have been clearly indicated and species should rather be delimited by the use of character combinations (Rollins 1952). Rollins' statement proved very true in this study of *Zygophyllum*. Schweickerdt (1937) and Porter (1969), after studying the genera *Tribulus* and *Kallstroemia* (Zygophyllaceae) respectively, concluded that members of these genera in arid and semi-arid regions display a large range of variation in vegetative aspects which can be attributed to concomitant variation in climatic and edaphic conditions. In *Zygophyllum*, which prefers arid and semi-arid habitats, a similar trend exists.

Vegetative characters

Habit

Zygophyllum species are shrubs or shrublets exhibiting a wide range of habits. The majority are many-stemmed, woody shrubs with erect or spreading branches or sometimes with a rounded habit. *Z. prismatocarpum* is an example of an erect shrub and *Z. retrofractum* one with a rounded habit. A few species have woody bases from where longer and slender stems scramble or ascend into and over nearby plants. Heights attained by the shrubby species vary considerably and range from 0.5 to 1.5 m. Exceptional heights of 2 m and more are attained only by scramblers like *Z. foetidum* and rarely *Z. leptopetalum*. Some *Zygophyllum* species can be regarded as shrublets, attaining heights of less than 0.5 m, like *Z. applanatum* and *Z. pterocaule* which have prostrate or decumbent habits, respectively. Only three species, the widespread *Z. simplex* and its allies, *Z. inflatum* and *Z. spongiosum*, are herbaceous annuals or at most biennials with a prostrate to semi-prostrate or erect habit. The majority of Australian *Zygophyllum* species belong to this last category (Eichler 1986). The habit of *Zygophyllum*

species as such is not of taxonomic importance but in combination with other morphological characters, it can be a useful tool in the delimitation of species.

Stems

Characters of the older stems of *Zygophyllum* species are of limited taxonomic value. Sonder (1860) considered the 4-angled, old stems of some species as important but currently this character is considered unreliable. The young stems vary considerably with regard to morphology and offer a number of stable characters that are of taxonomic importance. A very useful character of young stems is the **shape in cross section** which is visible in **fresh** and preserved material and best observed on the young stems near the growing tip. Several categories are distinguished (Figure 3.1):

- round with a flat ventral area and two prominent lateral ridges or with several less prominent striae.
- round with a distinct ventral groove.
- round and winged with two wings in a vertical plane.
- round and winged with a single wing in a vertical plane.
- rhombic or ellipsoid with no ridges or striae at all.
- striate all around.

The shape in cross section of the young stems is used in the delimitation of § *Prismatica* (winged stems) and § A*lata (*ventrally grooved stems). Stem striations are rare in *Zygophyllum* species and occur in *Z. maculatum* and *Z. leptopetalum* in combination with trichomes. Together these characters are stable and of taxonomic importance. This is in contrast to the stable striae found on the stems of all *Z. pubescens* specimens, but which occur together with an unstable indumentum, which makes the character combination unreliable. Porter (1969) considered striations on the stems of *Kallstroemia* species (*Zygophyllaceae*) of no taxonomic importance as they occur in all the species and become visible only after desiccation of the somewhat succulent stems. In *Zygophyllum*, **stem striations** are a rare phenomenon, but when present it is a stable character of taxonomic importance.

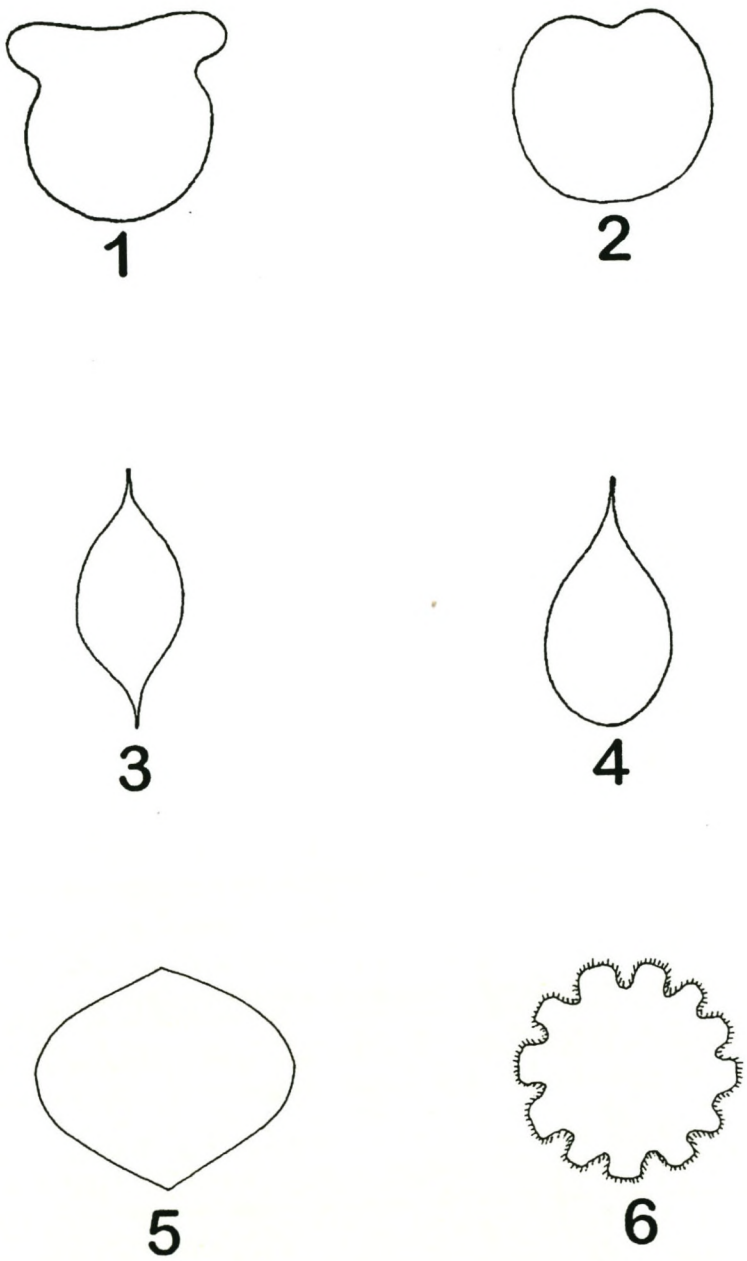


Figure 3.1. Stem shapes in cross section. 1, round with a flat ventral area and two prominent lateral ridges; 2, round with a distinct ventral groove; 3, round and winged with two wings in a vertical plane; 4, round and winged with a single wing in a vertical plane; 5, rhombic without any ridges or striae; 6, striate all around.

Indumentum

The majority of *Zygophyllum* species lack any kind of indumentum. In the rare instances when an indumentum is present, it can assist in the delimitation of some taxa. The type of pubescence found in *Zygophyllum* is always unicellular, but differs in the two subgenera. In subgenus *Zygophyllum* the hairs are elongate and up to 1—1.5 mm long, as in *Z. teretifolium* and *Z. hirticaule* or it can be short and sparse, as in *Z. leptopetalum* and *Z. maculatum*. In the subgenus *Agrophyllum* the indumentum is considered as a more stable character and consists of two-armed, T-shaped, appressed trichomes which, densely or sparsely, cover all vegetative parts, resulting in a white or whitish appearance. This type of indumentum is restricted to § *Cinerea* and § A*lata*. Glandular trichomes are rare in *Zygophyllum* and limited to subgenus *Agrophyllum* where it is found in abundance on all young parts of *Z. decumbens* var. *decumbens*. In several *Zygophyllum* species the sepals are covered adaxially with glandular hairs, or sparsely covered with short and straight hairs or woolly hairs, whereas the rest of the plant is glabrous. The presence of hairs or glands on sepals is unreliable and of little taxonomic value. Sonder (1860) described *Z. meyeri* as a new species, and one of the characters he used was the presence of woolly, curly, white hairs on its sepals. Because of the unreliability of this character, *Z. meyeri* is currently placed into synonymy of *Z. foetidum.*

Stipules

Stipules are present in all *Zygophyllum* species and they display large variation in **shape** varying from navicular, filamentous, triangular, narrowly triangular to subrotund, ovate, obovate, broadly obcordate to biparted (Figure 3.2). The stipule shape of the majority of species lies within the triangular, narrowly triangular range and cannot reliably be used as a taxonomic criterion. However, the stipule shapes that lie outside this range are taxonomically useful, e.g. the obcordate stipules of *Z. incrustatum* and the navicular stipules of *Z. cordifolium*. The shape of the stipules is best studied on young stems before secondary stem growth results in their distortion. In subgenus *Zygophyllum* the **number** of stipules at nodes varies. This is caused by the incomplete evolutionary process of stipule-fusing. In some species this process is already completed, resulting in single, interpetiolar stipules present at nodes on the ventral as well as dorsal sides of the stems, e.g. *Z. macrocarpon,* or

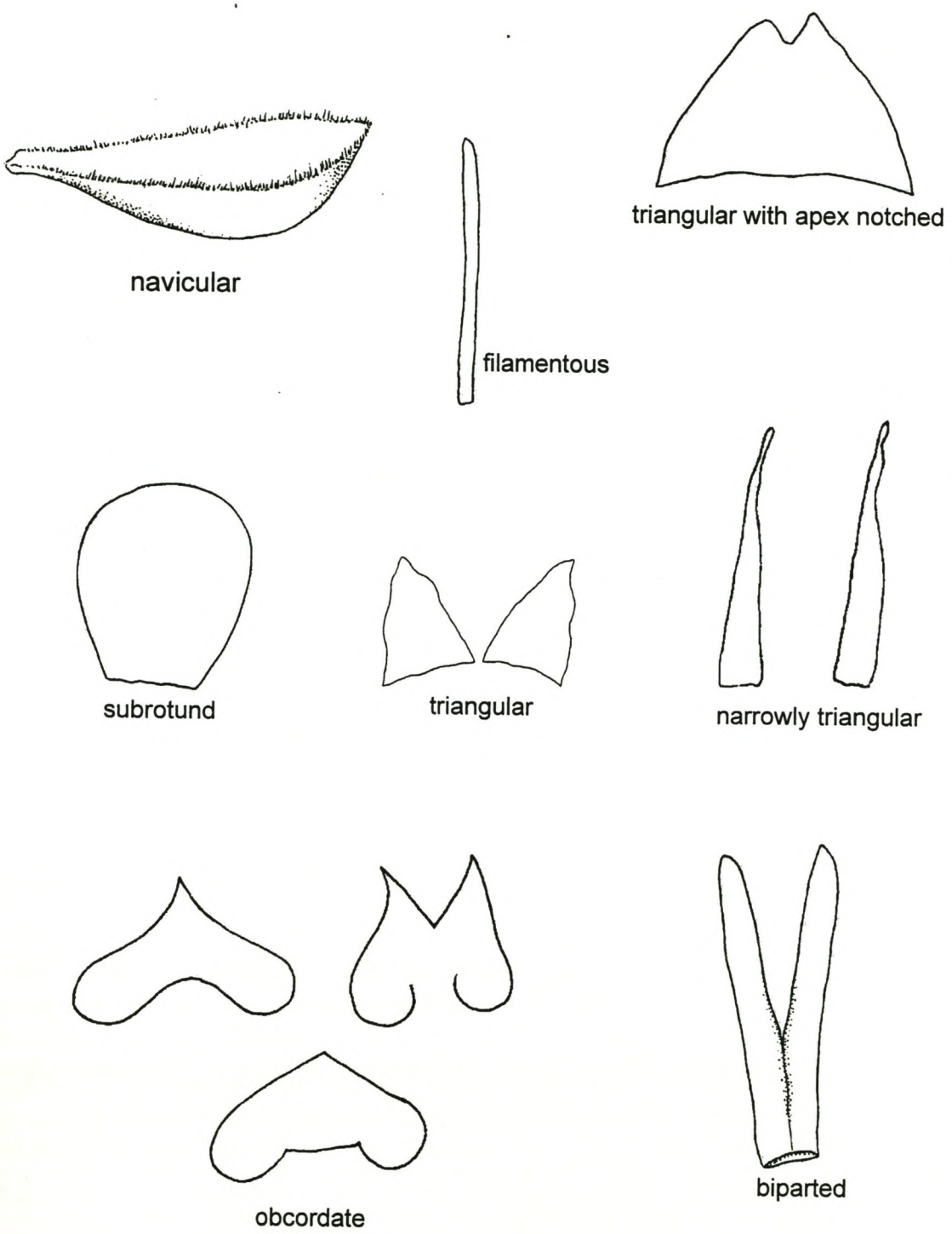


Figure 3.2. Various stipule shapes occurring in *Zygophyllum*.

two separate ventral stipules and a fused or single dorsal stipule present in *Z. fulvum* and *Z. spitskopense*. Only *Z. maritimum* displays completely unfused stipules, with two separate ventral and two separate dorsal stipules at its nodes. Sometimes young stipules, which are completely fused at base, display an apical notch of varying depth. This notch usually becomes more pronounced as the stipules mature and is distorted by secondary stem growth. Stipule-fusing is almost absent in subgenus *Agrophyllum* and most species display two separate stipules on both ventral and dorsal sides of stems. The exception here is *Z. stapffii,* which displays interpetiolar or fused stipules, and the three species in § *Alata* which display fused and free stipules arranged alternately along its stems. The number of stipules at the nodes is usually stable for a species and is of taxonomic value. Stipules are usually caducous but some species display semi-permanent stipules with the basal parts remaining and in some species the stipules become spinescent, e.g. *Z. spinosum*, which is a diagnostic character for the species.

Rachis apex

The bifoliolate leaves of *Zygophyllum* are regarded as a reduction of the pinnate leaf type found in some *Zygophyllaceae* (Weberling 1956). The rudimentary pinnae found between leaflets or at the apex of the petiole when a petiole is present,are the remains of the leaf rachis and have a different morphological development to the stipules (Weberling 1956). In the present study the remains of the leaf rachis or rudimentary pinnae is termed "rachis apex" and illustrated in Figure 3.3. The shape of the **rachis apex** usually corresponds to the shape of the stipules for a particular species. The rachis apex of sessile leaves is usually slightly differently orientated and often slightly larger or thicker than the stipules present at the same node. A few petiolate species like *Z. foetidum* and *Z. cretaceum* display small, green, foliar rachis apices.

Leaves

Leaves of *Zygophyllum* are always opposite with the exception of the leaves of species in § *Annua.* Only the older leaves of species in this section are opposite, whereas all younger leaves are situated opposite a branch, representing a sympodial branching of the stem. In *Zygophyllum* a variation of **leaf types** occurs,

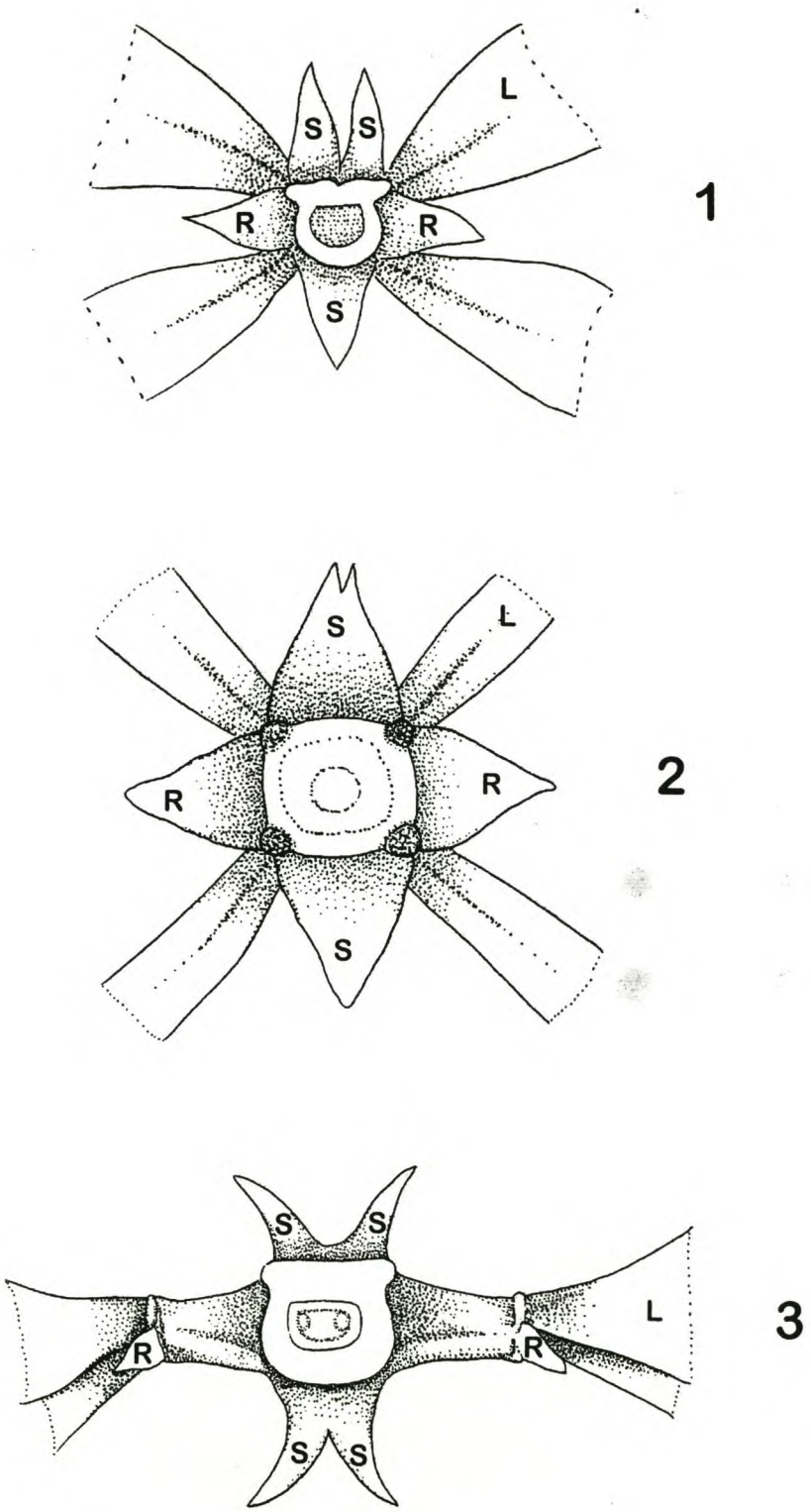


Figure 3.3. Position and number of stipules and rachis apices found in some *Zygophyllum* species. 1, Three stipules and two rachis apices at node of the sessile, bifoliolate leaves of *Z. fulvum*, *Van Zyl* 4248; 2, Two stipules, one with a notched apex and two rachis apices at the node of the sessile, bifoliolate leaves of *Z. namaquanum*, *Van Zyl* 3824; 3, Four stipules and two rachis apices at node of the petiolate, bifoliolate leaves of *Z. maritimum, Van Zyl* 3631.

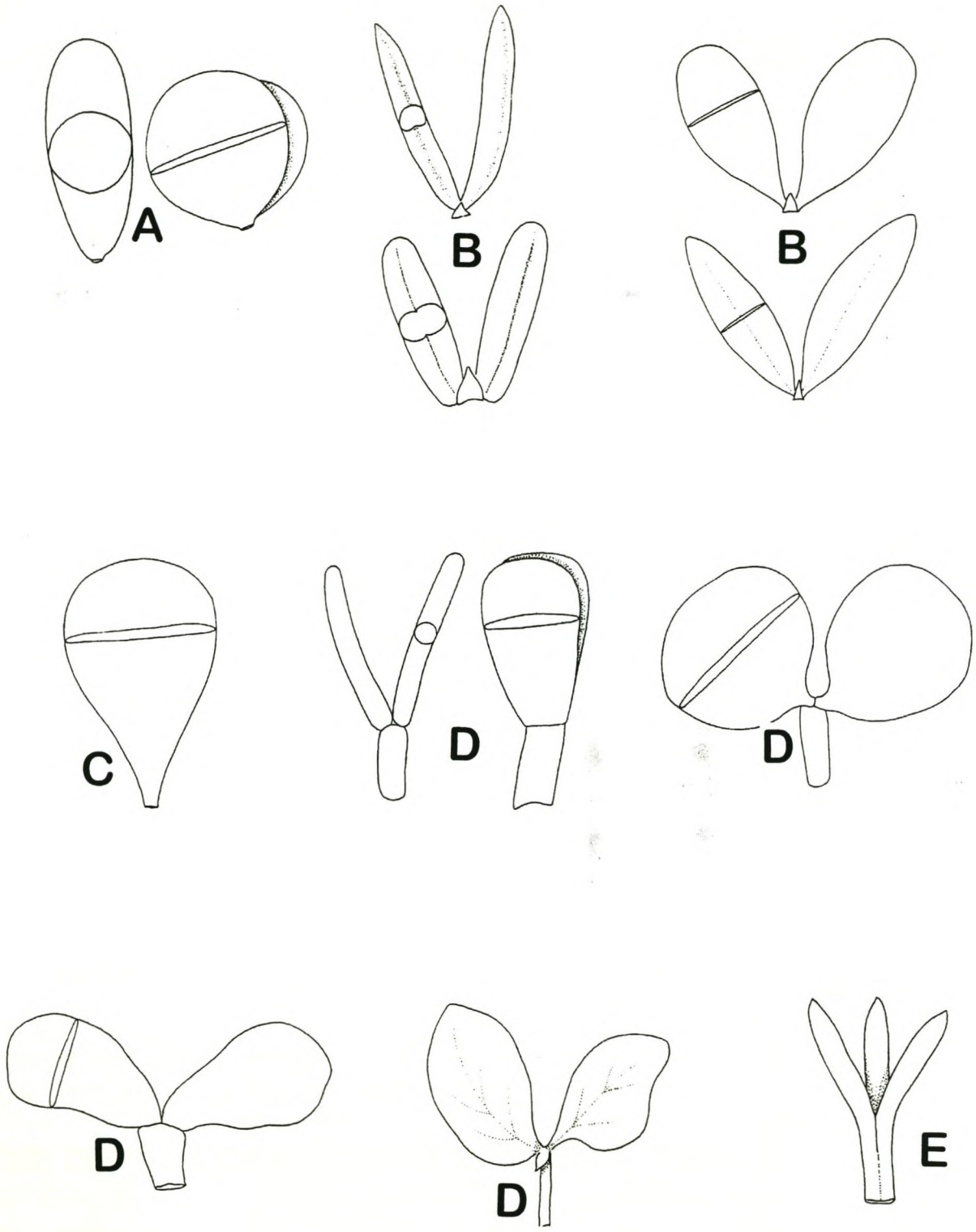


Figure 3.4. Leaf types found in *Zygophyllum*. A, sessile, simple; B, sessile, bifoliolate; C, petiolate, simple; D, petiolate, bifoliolate; E, petiolate, trifoliolate.

which can be sessile and simple; sessile and bifoliolate; petiolate and simple; petiolate and bifoliolate; petiolate and trifoliolate (Figure 3.4 and Table 3.1). Only one species, *Z. schreiberanum*, has trifoliolate leaves. The trifoliate state results from the rachis apex becoming foliar and larger, reaching the same length as the leaflets. On the flowering branches of some species with petiolate, bifoliolate leaves, intermediate leaf types occur, with leaves reduced to a petiolate, unifoliolate or even sessile state (Figure 5.1). The leaf type of the majority of *Zygophyllum* species is usually stable and is, in combination with other characters, of considerable taxonomic value in delimiting taxa. However, in two species, *Z. pubescens* and *Z. leucocladum,* a variable leaf type is found with leaves either shortly petiolate or sessile (accordingly repeated in Table 3.1). A wide range of leaf **shapes** occur, from terete or linear to all possible shapes up to orbicular in outline (Figure 3.4). The most common shape is a flat and obovate lamina. Within some species, leaf shape is a variable character, but in the majority of species leaf shape is a stable character which, in combination with other characters, can be used in delimiting taxa. Leaf **size** varies within species in accord with changing climatological conditions and is considered of little taxonomic importance. Leaf **pubescence** corresponds with the indumentum as found on other vegetative parts. An articulation zone usually occurs at the base of *Zygophyllum* leaflets or leaves. This zone facilitate the drought deciduous response present in most species. Table 3.1 summarizes the leaf characters of the species of *Zygophyllum.*

Table 3.1. Leaf characters present in *Zygophyllum* species arranged according to shape of lamina (two species with variable state **indicated in boldface**).

SPECIES	SIZE IN MM	SHAPE OF LAMINA
SUBGENUS AGROPHYLLUM		
SESSILE, SIMPLE		
Z. simplex	4–12 x 1.5–4	obovoid or globose
Z. spongiosum	6–11 x 2–3	obovoid or globose
Z. inflatum	7–14 x 3–4	obovoid

Z. prismatocarpum	16–30 x 14–18	suborbicular or widely obovate
Z. patenticaule	15–17 x 13–18	suborbicular or widely obovate
Z. pterocaule	20–30 x 20–30	suborbicular
PETIOLATE, BIFOLIOLATE		
Z. segmentatum	5–7.5 x 2–2.5	terete + abaxial groove
Z. cylindrifolium	8–15 x 2	terete + adaxial groove
Z. stapffii	20–45 x 20–40	subrotund, rotund
Z. clavatum	4–9 x 2–4.5	obovate, clavate
Z. retrofractum	2–4.5 x 1.5–3	obovate, subrotund
Z. applanatum	5–7 x 4–7	obovate, subrotund
Z. decumbens	7–17 x 6–11	obovate, subrotund
Z. longicapsulare	7–15 x 5–12	obovate, rotund
Z. tenue	5–7 x 2–3	obovate, oblong
Z. turbinatum	3–4 x 1.5	obovate, oblong
Z. chrysopteron	2–2.5 x 1.5–2	obovate, oblong
Z. giessii	6–8 x 2–3	obovate
Z. microcarpum	6–11 x 2–3	obovate
Z. rigidum	8–15 x 5–9	obovate
Z. longistipulare	5–9 x 3–4	obovate
SUBGENUS ZYGOPHYLLUM		
SESSILE, SIMPLE		
Z. cordifolium	20–50 x 16–60	subrotund or obovate
Z. fusiforme	13–27 x 12–25	subrotund or obovate
SESSILE, BIFOLIOLATE		
Z. spinosum	10–22 x 2–2.5	linear + adaxial groove
Z. pygmaeum	7–14 x 1.5–3	linear + adaxial groove
Z. rogersii	5–7 x 1	linear + adaxial groove

Z. teretifolium	12–45 x 2–4	terete, succulent + adaxial and abaxial groove
Z. botulifolium	7–13 x 2–3	terete, succulent, not grooved
Z. cuneifolium	12–23 x 3.5–4	cuneate
Z. spitskopense	12–16 x 2–4	obovate or cuneate
Z. divaricatum	5–8 x 3.5–4.5	obovate, base obtuse or cuneate
Z. hirticaule	20–40 x 13–25	obovate, base cuneate
Z. flexuosum	11–17 x 5–7	obovate, base cuneate
Z. namaquanum	5–7 x 2–3.5	obovate
Z. porphyrocaule	10–14 x 3–5	obovate
Z. sessilifolium	11-20 x 3–8	obovate
Z. calcicola	13–19 x 4–8	obovate or elliptic
Z. fulvum	10–30 x 3–15	obovate or elliptic
Z. fuscatum	12–16 x 2–5	obovate or elliptic
Z. pubescens (sessile or petiolate)	7–20 x 2–5	obovate or elliptic
Z. leucocladum (sessile or petiolate)	7–12 x 2–5	obovate or elliptic
Z. swartbergense	12–20 x 3–6	elliptic, falcate
PETIOLATE, SIMPLE		
Z. orbiculare	20–50 X 16–60	orbicular or obovate-spathulate
PETIOLATE, BIFOLIOLATE		
Z. maculatum	6–13 x 1.5–2	terete + adaxial groove
Z. morgsana	15–30 x 12–19	obovate, subrotund
Z. leptopetalum	17–25 x 10–17	obovate, asymmetrical
Z. cretaceum	23–28 x 15–22	obovate, asymmetrical
Z. foetidum	25–43 x 16–30	obovate, asymmetrical
Z. lichtensteinianum	8–17 x 5–6	obovate, asymmetrical
Z. macrocarpon	35–50 x 30–45	obovate, asymmetrical
Z. incrustatum	5–7 x 2–3	elliptic
Z. maritimum	14–19 x 5–10	obovate, elliptic

Z. pubescens (sessile or petiolate)	7–20 x 2–5	obovate, elliptic
Z. leucocladum (sessile or petiolate)	7–12 x 2–5	obovate, elliptic
Z. debile	11–26 x 4–7	obovate, elliptic, ovate
PETIOLATE, TRIFOLIOLATE		
Z. schreiberanum	4–15 x 1–2	terete + adaxial groove

Floral characters

Inflorescence

The majority of *Zygophyllum* species display **indeterminate inflorescenses** (Cronquist 1981) or **polytelic synflorescences** (Weberling 1992). This type of inflorescence lacks a terminal flower and is represented in *Zygophyllum* species as single or clustered, axillary flowers. Cymous inflorescences, considered more primitive (Takhtajan 1980), are restricted to subgenus *Agrophyllum*, and occur in the three species of § *Prismatica* as well as in one taxon of § *Bipartita*, viz. *Z. decumbens* var. *decumbens*. All four of these species exhibit a scorpioid cyme, contracted and dense in *Z. prismatocarpum* and *Z. decumbens* var. *decumbens,* elongated and with regularly spaced flowers in *Z. patenticaule* and short and reduced with few flowers in *Z. pterocaule.*

Flowers

The majority of the species in subgenus *Agrophyllum* display small, perfectly actinomorphic **flowers** with unmarked petals which are usually white, rarely yellow or orange. In subgenus *Zygophyllum* a tendency towards zygomorphism is detected when analyzing the basal markings of most species and petal orientation of some species. The basal markings on many flowers are usually more prominent on the two posterior petals than on the anterior three and during anthesis a few species display a different petal orientation. When these two characters are present it can be considered as a partially zygomorphic state. The two posterior petals are reflexed and the three anterior petals extended. Species with a different orientation

of the petals are rare in *Zygophyllum* and this state usually occurs in combination with red floral veins which are also rare. Three species, *Z. leptopetalum*, *Z. sessilifolium* and *Z. spitskopense,* all of § *Capensia,* exhibit these characters.

Sepals

The **number** of sepals found in *Zygophyllum* species is of little taxonomic value. All species have five sepals, except *Z. morgsana,* which is tetramerous and thus have four sepals only. The **arrangement** of the sepals is in a quincunciale manner and not imbricate as reported by most authors (Dyer 1975, Cronquist 1981). Differences in the structure of the sepals occur between the two subgenera. In the subgenus *Agrophyllum* the sepals articulate, the outer ones are usually succulent and cucullate and all have membranous margins that become scarious with age, e.g. *Z. prismatocrpum* and *Z. applanatum*. In the subgenus *Zygophyllum* the sepals do not articulate but are often somewhat adnate at the base. They are not succulent and also display membranous margins becoming scarious with age. Sepal **shape** varies from ovate, obovate or oblong with an acute, attenuate or obtuse apex. Sepals are usually glabrous, but if trichomes are present, they usually correspond to the type found on other parts of the same plant. In a few species the abaxial side of the sepals are sparsely hairy with short, straight hairs, or woolly, or glandular in contrast to the glabrous state of the rest of the plant. Sepals may be persistent or deciduous. Characters of the calyx of *Zygophyllum* species are not considered of much taxonomic importance.

Petals

Petals are convolute in the bud, becoming radiating, patent or reflexed during anthesis, after which they end up convolute and shriveled around the style before they drop off. The petals are inserted at the base of the nectar disc opposite the staminal scales of the outer whorl. They are free and alternately arranged with the sepals. The **number** of petals, as in the case of the sepals, is of little taxonomic value since all species have five petals, except *Z. morgsana* which is tetramerous, with four petals only. This is in contrast to the Australian *Zygophyllum* species which have 3—5 petals per flower and where petal number is of taxonomic value (Black, 1963; Eichler, 1981). Two prominent characters which are very useful to distinguish

between the subgenera are the **colour** of the petals and the **markings** on the petals. In subgenus *Agrophyllum* the majority of species have white petals without any markings. The exception here are the species in § *Alata* and in § *Annua,* which have white or pale yellow or peach petals. The majority of species in subgenus *Zygophyllum* have petals in different shades of yellow. White petals are rarely encountered and usually occur in combination with red veins and a tendency to zygomorphism of the flower. This is found in *Z. sessilifolium*, *Z. spitskopense* and *Z. calcicola*. White petals without red veins but which are marked at the base, are rare but occur in some populations of *Z. fulvum* and *Z. maritimum*. The presence of basal petal markings is a diagnostic character for the subgenus *Zygophyllum.* These markings can be red, brown, khaki or deep yellow, are variable in shape from vaguely V-, W-, U-, to M-shaped and the markings are single or tiered (Figures 7.27.1; 7.28.1; 7.37.1). These markings are sometimes found together with blotches or short stripes or bands of different colours in the throat of the flowers. One species, *Z. rogersii*, has carmine petals without markings at its base (Figure 7.29.1). Although a variation in the petal markings occurs, this character is not considered of much taxonomic value. Petal **shape** differs between the two subgenera of *Zygophyllum*. In subgenus *Agrophyllum* petal shape varies and can be spathulate, obovate or oblanceolate and usually with a long claw. Petal shape is usually constant within a species and thus of taxonomic use. In subgenus *Zygophyllum* petal shape also varies and can be elliptic, ovate, obovate, widely obovate or subrotund, usually with an emarginate apex and always with a short claw. The variable petal size is of little taxonomic significance. Petal **size** is variable and not of any taxonomic significance. Petal **orientation** differs between the two subgenera. In subgenus *Agrophyllum* the petals are usually extended and stiffly wide-open, whereas in subgenus *Zygophyllum* the petals are usually patent or reflexed during anthesis, resulting in a more pliable, softer appearance.

Androecium

The androecium of *Zygophyllum* is actinomorphic and obdiplostemonous and consists of ten, free **stamens**, arranged in two whorls of five each (Figure 3.5). The stamens of each whorl are of a similar length, whereas a slight difference in length occurs between the two whorls. All the filaments are terete and inserted below the

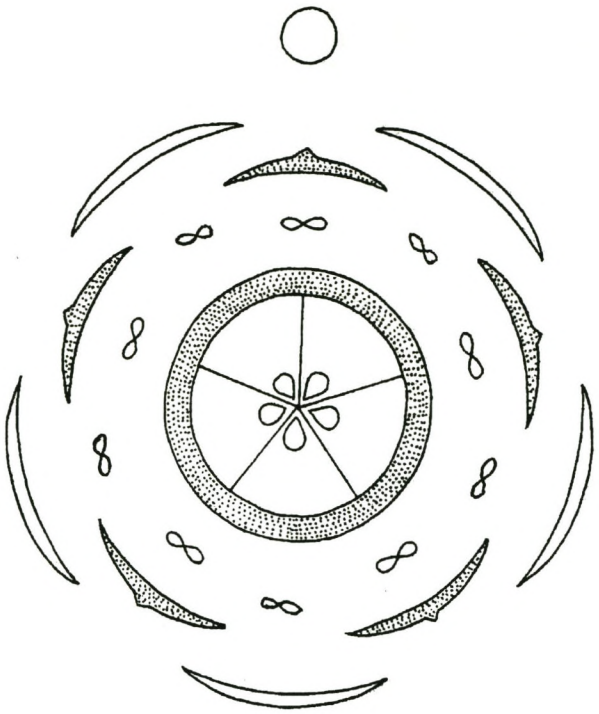


Figure 3.5. Floral diagram of *Zygophyllum* to illustrate the position of the various floral elements.

nectar disc. In subgenus *Agrophyllum* the filaments are usually longer than the style and sometimes longer than the petals. In the subgenus *Zygophyllum* filaments are usually of a similar or a slightly shorter length than the style. When the flowers first open, the filaments are reflexed and the anthers still closed. The anthers soon become extended. During anthesis the filaments enclose the style, probably assisting self-pollination, after which they return to a radiating, widely open orientation before they wither. The anthers are bi-thecous, dorsifixed, longitudinally dehiscent and introrse.

In all species studied a **staminal scale**, adnate to the ventral side of each filament, is present. These staminal scales are usually concave in side-view, and together, enclose and protect the ovary. Variation occurs in the shape, laceration of the margins and the presence or absence of papillae on the surface of the scales (Figure 3.6; Table 3.3). Finding flowers of a similar age or development is difficult and measurements are subjective. Measuring the filament and scale lengths are also problematic because of the small sizes involved as well as the somewhat curved nature of the filaments. The ratio between the length of the filament and the length of the scale varies from 5 : 1 (filament long and scale short) at the one end of the range to 5 : 4 (filament long and scale nearly as long) at the other end. In the majority of species the ratio lies between 2 : 1 and 3 : 1 and cannot successfully be used as a taxonomic criterion. Some ratios at the ends of the range are of taxonomic value and of use in delimiting a section, e.g. the three species in § *Prismatica* all have a ratio of 5 : 1, or species, e.g. *Z. sessilifolium* and its close ally *Z. spitskopense,* as well as *Z. schreiberanum* with ratios of 3 : 2, and *Z. leptopetalum* with a ratio of 5 : 4 (Table 3.2). The characters of the staminal scales are stable within species and considered of taxonomic importance. Table 3.2 summarizes the filament length / staminal scale length, scale type and nectar disc type present in the subgenera, sections and species of *Zygophyllum*.

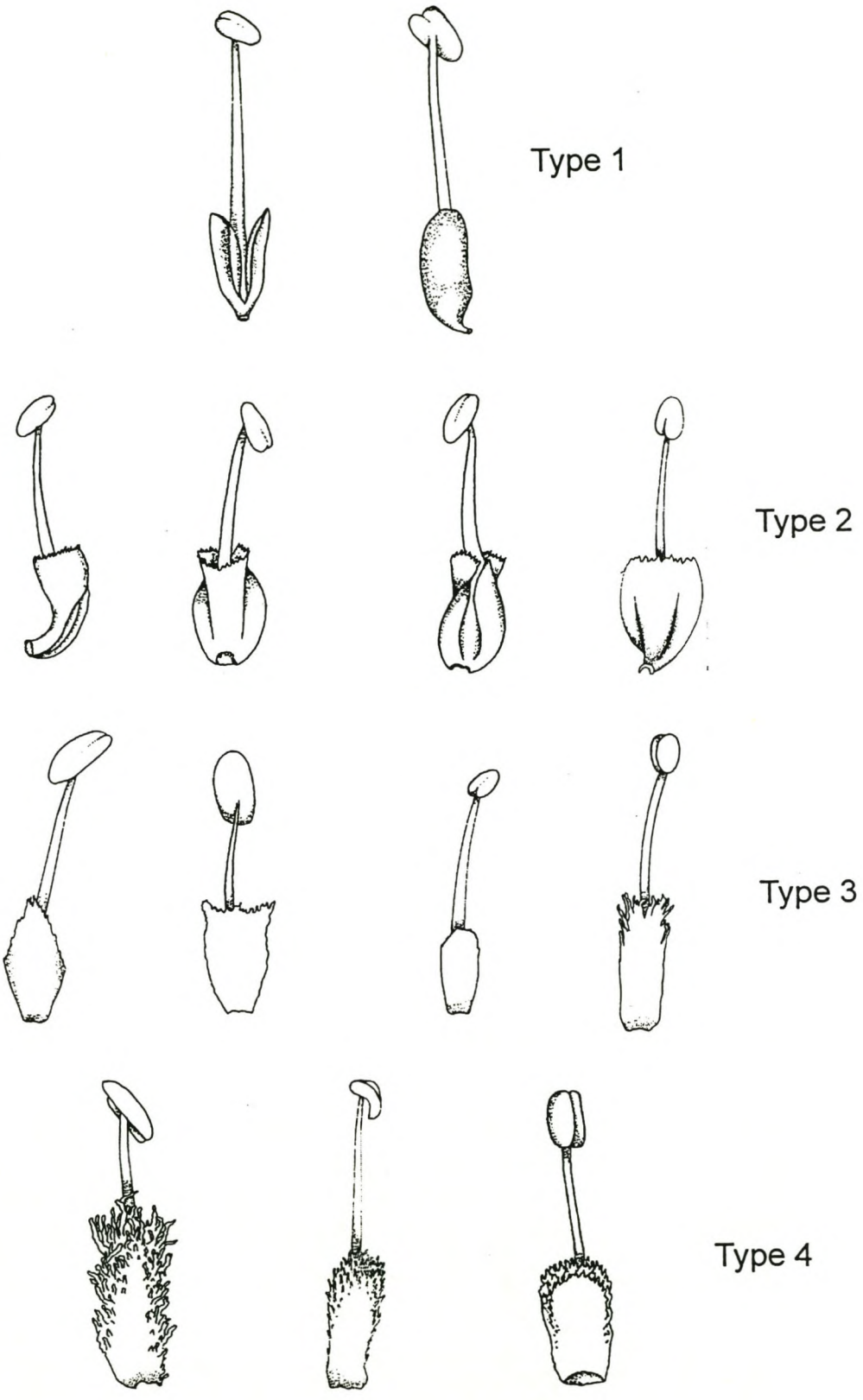


Figure 3.6. Staminal scale types found in *Zygophyllum*. Type 1, left - ventral-view, right - side-view; Type 2 (from left to right), side-view, ventral-view, dorsal-view, ventral-view of alternate scale with apex not enfolding filament; Type 3, margins variably lacerate but without papillae on surface of scale; Type 4, margins lacerate and with papillae on surface of scale (species in Table 3.2 and descriptions in Table 3.3).

Table 3.2. Filament length : staminal scale length ratios, types of staminal scales and types of nectar discs present in *Zygophylum*.

SECTION	SPECIES	FILAMENT : SCALE RATIO	SCALE TYPE (Figure 3.6)	NECTAR DISC TYPE (Figure 3.7)
SUBGENUS AGROPHYLLUM				
Annua	Z. simplex	3 : 1	1	4
	Z. spongiosum	3 : 1	1	4
	Z. inflatum	3 : 1	1	4
Prismatica	Z. prismatocarpum	5 : 1	1	3
	Z. patenticaule	5 : 1	1	3
	Z. pterocaule	5 : 1	1	3
Bipartita	Z. decumbens	3 : 1	1	2
	Z. retrofractum	2 : 1	1	4
	Z. turbinatum	2 : 1	1	4
	Z. chrysopteron	2 : 1	1	4
	Z. clavatum	3 : 1	1	2
	Z. tenue	3 : 1	1	4
	Z. segmentatum	2 : 1	1	4
	Z. cylindrifolium	2 : 1	1	4
	Z. applanatum	2 : 1	1	2
Alata subs. *Alata*	Z. microcarpum	2 : 1	2	2
	Z. rigidum	2 : 1	2	2
	Z. longistipulare	3 : 1 or 2 : 1	2	2
Cinerea	Z. longicapsulare	3 : 1	3	2
	Z. giessii	2 : 1	3	2
Grandifolia	Z. stapffii	3 : 2	3	2
SUBGENUS ZYGOPHYLLUM				
Paradoxa	Z. cordifolium	2 : 1	3	1
	Z. fusiforme	3 : 1	3	1
	Z. orbiculatum	?	?	?
Capensia - leaves sessile, terete	Z. teretifolium	2 : 1	3	1
	Z. botulifolium	2 : 1	3	1
leaves sessile, linear	Z. spinosum	3 : 1	3	1
	Z. pygmaeum	3 : 1	3	1
	Z. rogersii	2 : 1	3	1
leaves sessile, obovate / other	Z. namaquanum	3 : 1	3	1
	Z. divaricatum	3 : 1 or 2 : 1	4	1
	Z. sessilifolium	3 : 2	4	1
	Z. spitskopense	3 : 2	4	1
	Z. cuneifolium	2 : 1	4	1
	Z. hirticaule	2 : 1	4	1
	Z. calcicola	2 : 1	4	1
	Z. fulvum	2 : 1	4	1
	Z. porphyrocaule	2 : 1	4	1
	Z. swartbergense	3 : 1	3	1
	Z. flexuosum	3 : 1	3	1
	Z. fuscatum	3 : 1	3	1

leaves petiolate / sessile	Z. pubescens	3 : 1	3	1
	Z .leucocladum	3 : 1	3	1
leaves petiolate bifoliolate	Z. lichtensteinianum	3 : 1	3	1
	Z. incrustatum	3 : 1	3	1
	Z. maritimum	2 : 1	3	1
	Z. debile	2 : 1	3	1
	Z. cretaceum	3 : 1	4	1
	Z. foetidum	3 : 1	4	1
	Z. macrocarpon	3 : 1	4	1
	Z. maculatum	2 : 1	4	1
	Z. leptopetalum	5 : 4	4	1
leaves petiolate, trifoliolate	Z. schreiberanum	3 : 2	4	1
Morgsana	Z. morgsana	2 : 1	3	1

Table 3.3. Short descriptions of the types of staminal scale found in *Zygophyllum*

Type 1	Type 2	Type 3	Type 4
Staminal scales biparted almost to the base, each segment oblong, apex obtuse or obliquely lobed, margins entire, base narrowed, segment ± 1/5 to 1/3 the length of the filament. The orientation of staminal scales is affected by the relation between the scales and the ovary which could be spherical, lobed or parted. This causes the alternate different orientation of the scales depending on the available space between the lobes or partitions of the ovary (Figure 3.6.1).	Staminal scales simple, nearly transparent, obovate, apices truncate, denticulate, lateral margins entire, bases rounded, alternately with different orientations, one scale rolled up, nearly enfolding the filament and the next scale in the usually flat or slightly concave, unrolled position, scale ±1/2 the length of the filament (Figure 3.6.2).	Staminal scales simple, usually obovate in shape, not completely flat but somewhat curved around the filament, with truncate, rounded, V-shaped or acute apices and upper lateral and apical margins lacerate, fimbriate or denticulate, without any papillae on the ventral or dorsal surfaces. This type is variable within a species and is of some taxonomic use when used in combination with other characters (Figure 3.6.3).	Staminal scales simple, usually obovate in shape and with obtuse apices, apical and lateral margins usually lacerated and sparsely or densely covered with curly papillae of various lengths, arranged along the border or only on the upper half of the scale on both the ventral and dorsal sides. This type of scale varies within a species but is of taxonomic use when used in combination with other characters (Figure 3.6.4).

Nectar disc

An intrastaminal, hypogynous nectar disc is present in all *Zygophyllum* species. There is probably a co-function between the nectar disc and the staminal scales, as the arrangement of the scales forms a closed space round the base of the ovary in which nectar is collected. Although not tested for nectar or sugary compounds, a clearly visible liquid collects on top of the nectar disc. In *Z. stapffii* "small nectaries", in the form of groups of darker cells, are seen on the disc. Variation that is stable and of taxonomic importance at subgeneric and section level occurs in the nectar discs of species of subgenus *Agrophyllum.* The nectar discs of species of subgenus *Zygophyllum* displayed no variation and are always densely papillate. The density and length of the papillae vary somewhat and this variation might be correlated to the developmental age of the flower and are thus not considered of taxonomic importance. Nectar discs covered with papillae is described as papillate (Figure 3.7.1 and Tables 3.2 and 3.4). This type of nectar disc is always regularly ten-angled in top-view. The angles correspond to indentations made by the attachment of the filaments and their staminals scales. When the staminal scales are removed, ten prominent scars can be seen on the side of the disc. The regularly ten-angled, papillate nectar disc is of diagnostic value at subgeneric level, but does not contribute any distinguishing characters at species level. In contrast to the subgenus *Zygophyllum* a larger variation occurs in the morphology of the nectar disc of subgenus *Agrophyllum*. It is always without papillae, a state described as smooth and secondly, a variation in its shape occurs (Figure 3.7.2—4 and Tables 3.2 and 3.4). The variation in its morphology is stable within a species and used as a delimiting character for sections *Annua*, *Prismatica, Cinerea* and *Alata* (Table 3.2).

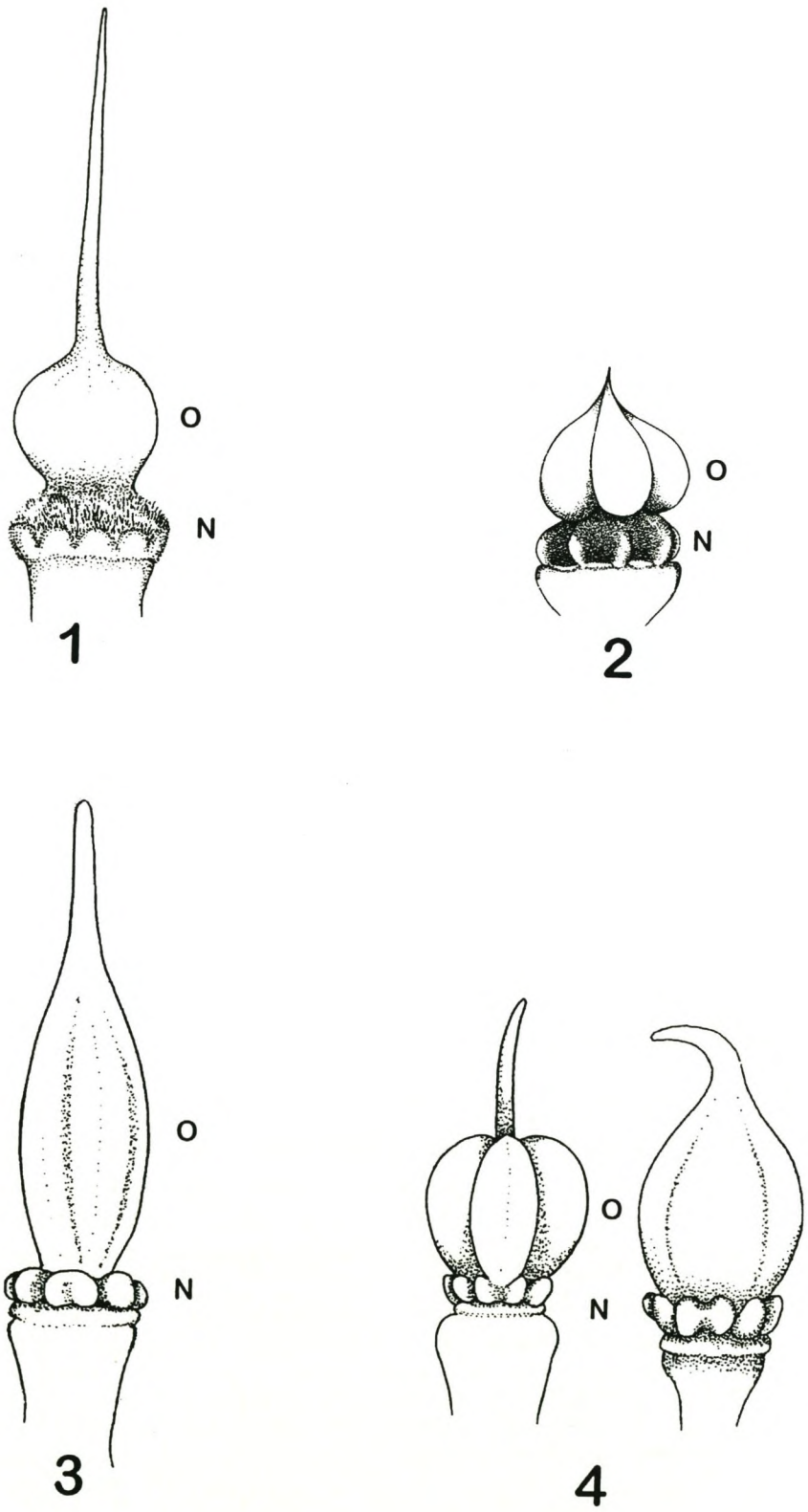


Figure 3.7. Different nectar discs (N)and some ovaries (O) of *Zygophyllum*. Nectar discs Type 1—4. (Table 3.2 lists the species for each type and Table 3.4 a description of each type).

Table 3.4. Short descriptions of the nectar discs found in *Zygophyllum*

Type 1	Type 2	Type 3	Type 4
Nectar disc papillate, regularly 10-angled in top-view, scars of removed staminal scales visible in side-view (Figure 3.7.1). **Subgenus *Zygophyllum***	Nectar disc smooth, 10-angled in top view, the disc sloping slightly towards its periphery, with 10 small lobes, ridges or projections, orientated downward, situated at its base or on the lower half of its sides. Scars of removed staminal scales visible in side-view (Figure 3.7.2). **Subgenus *Agrophyllum***	Nectar disc smooth, 10-lobed, lobes arranged in 5 pairs, each pair with a slightly raised central area and a sunken area between pairs, the disc as a whole slopes slightly towards its periphery (Figure 3.7.3). **Subgenus *Agrophyllum***	Nectar disc smooth, prominently 10-lobed, lobes arranged in 5 pairs, each pair orientated outwards and upwards (Figure 3.7.4). **Subgenus *Agrophyllum***

The variation found in the nectar disc of subgenus *Agrophyllum* is probably the result of pressure on or the physical restriction caused to the tissues of the nectar disc by the staminal scales which are inserted just below the disc. This statement is based on the presence of small, basal lobes found on some nectar discs which correspond to openings between the enclosing staminal scales. However, the prominent outward and upward orientation of the lobes found on the nectar disc of some *Zygophyllum* species is probably an evolutionary trend towards separate nectaries similar to those in the genus *Tribulus* (Zygophyllaceae; Schweickerdt 1937, Brown 1938). Some species of *Tribulus* display a nectar disc with lobes and indentations and some species display separate nectaries. The shape of the ovary, whether it is spherical, lobed or parted, probably also influences the shape of the nectar disc.

Gynoecium

The gynoecium in *Zygophyllum* consists of a sessile, (4) 5-locular, superior ovary, varying from globose, ovoid, conical, lobed, parted to rudimentary winged in shape (Figure 3.7). When globose, the ovary usually displays five, clearly visible sutures indicative of its 5-locular state. The ovary is usually glabrous or rarely hairy, as in *Z. microcarpum* and *Z. longistipulatum* (Figure 7.18.1), or globulate, as in *Z. longicapsulare* and *Z. applanatum* (Figure 7.7.1). Placentation is axile. The ovules are epitropous, variable in number from a few to many per locule. Some of the

ovules are abortive resulting in many empty or 1-seeded locules. The style arises from the summit of the ovary, is terete and has a terminal, simple, not persistent stigma. One species, *Z. simplex*, has a stigma that could be considered as slightly capitate. Although variation in the ovary exists and is of some taxonomic use, the emphasis was put on the immature and mature fruits.

Fruit

Fruit morphology of *Zygophyllum* species is variable and fruit types can be divided into two major groups based on the method of dehiscence.

- **capsules** which dehisce in a **loculicidal** way — subgenus *Zygophyllum*
- **schizocarps** which dehisce in a **septicidal** manner into five mericarps — subgenus *Agrophyllum*.

The loculicidal capsules break up into separate valves and disseminate the seeds close to the mother plant. The septicidal schizocarps separate into five mericarps which usually retain the seeds within and are dispersed as a unit over either a long or a short distance. The mericarps of some septicidal fruits also possess a dorsal suture which is sometimes present as a faint ridge along which splitting can occur, usually after dispersal, e.g. *Z. simplex* and its allies in § Annua. In each of the two major groups an exception occurs with regard to the method of dehiscence. In the fruit of *Z. morgsana,* subgenus *Zygophyllum*, the endocarp separates completely from the central axis but the exocarp remains intact resulting in incomplete splitting of the capsule. This type of fruit is classified as septifragal (Spjut 1994), because the fruit opens **incompletely**. In subgenus *Agrophyllum*, *Z. stapffii* displays a xerochastic method of dehiscence and fruits open in response to dry air and close again in response to moisture (opposite to hygrochasy). Thus, at least four distinct dehiscing methods occur in the fruits of *Zygophyllum.*

When mature the fruits of *Zygophyllum* display an exocarp and endocarp that are nearly free from each other. It is the mesocarp, which sometimes becomes highly succulent consisting of water storing tissues, that gives the fruit a succulent appearance. Succulent fruits are rare in subgenus *Zygophyllum*, occurring in only

four of its species, whereas it is common in subgenus *Agrophyllum*, occurring in almost 50% of its species. The predominance of succulent fruits found in subgenus *Agrophyllum* correlates with the concentration of its species in the extremely arid parts of southern Namibia and the Northern Cape (Figure 4.4). The endocarp of *Zygophyllum* fruits is smooth and shiny on the inside and is usually strong and permanent, determining the shape of the mature fruits. In contrast, the exocarp of mature fruits in both subgenera is sometimes thin and soft and eventually disintegrates, exposing the more permanent endocarp and its contents. *Z. cretaceum*, subgenus *Zygophyllum*, and all succulent fruits in subgenus *Agrophyllum* are examples of this state. Black (1963) and Eichler (1986) interpreted the succulent nature of some *Zygophyllum* fruits as drupes or drupaceous fruits. However, in the southern African *Zygophyllum* species, these succulent or drupaceous fruits, when dry, turned out to be only a collection of the usual five separate mericarps, consisting of the hardened endocarp, enclosing the seeds and enfolded by the partially disintegrating exocarp. The succulent, soft fruits of *Z. longicapsulare* as well as those of *Z. applanatum* are examples of this state (Figures 7.19.1; 7.7.1). *Zygophyllum* displays a large variation in the shape of its fruit, which is distinct for the two subgenera and diagnostic at subgeneric level (Figures 3.8—13).

Subgenus *Zygophyllum*

Fruits found in this subgenus are usually ridged on a dorsal suture along which splitting will occur. The ridges on the lobes vary in width. Some are thin and sharp, but the majority are blunt and slightly wider, whereas in a few species, the ridges are broad and flat (Figure 3.9 J & K). The fruits of subgenus *Zygophyllum* are categorized as 5-lobed and without ridges, 5-lobed with ridges or it can be 5-lobed with wings (Figures 3.8—10). The wings are usually membranous, reticulate-veined and at least 2 mm in width but can reach a width of 15 mm as found in *Z. morgsana*. These characters occur in combination with a spherical, subspherical, oblong, ovoid or prismatic fruit shape. Noteworthy is the near absence of succulency in this subgenus. Ridges are typically present on the fruits of the majority of species in subgenus *Zygophyllum* and of taxonomic value at subgeneric level. The type of

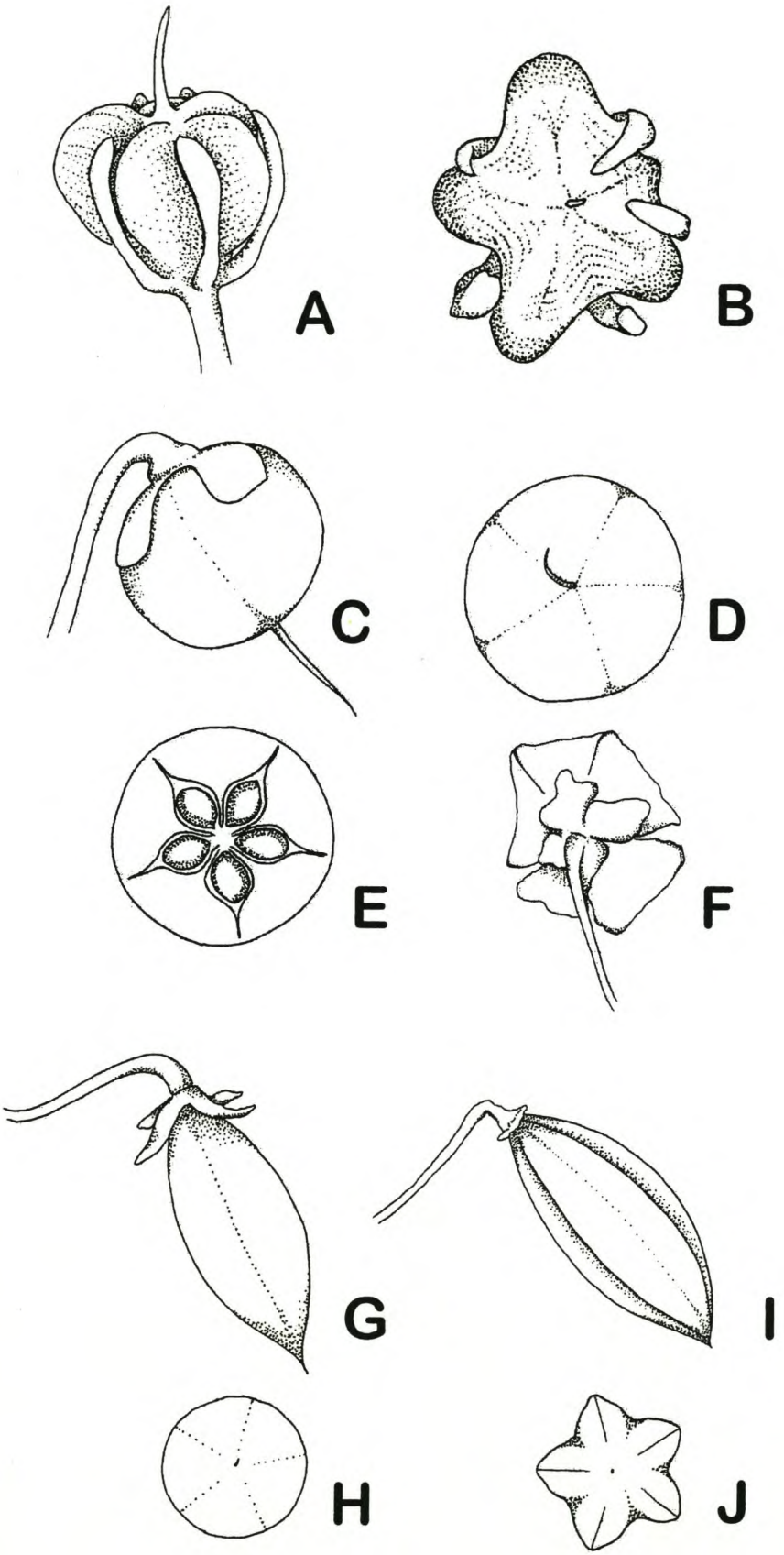


Figure 3.8. Fruits in subgenus *Zygophyllum* categorized as **not ridged** (not to scale). A—B, *Z. cretaceum, Van Zyl 4488*, C—F, *Z. flexuosum, Van Zyl 4291*, G—J, *Z. fusiforme, Van Zyl 4135*. A, side-view; B, top-view; C, side-view of succulent, fresh fruit; D, top-view of succulent, fresh fruit; E, cross section of succulent, fresh fruit; F, basal-view of dry, angular fruit; G, side-view of fresh, succulent fruit; H, top-view of fresh, succulent fruit; I, side-view of dry fruit; J, top-view of dry fruit.

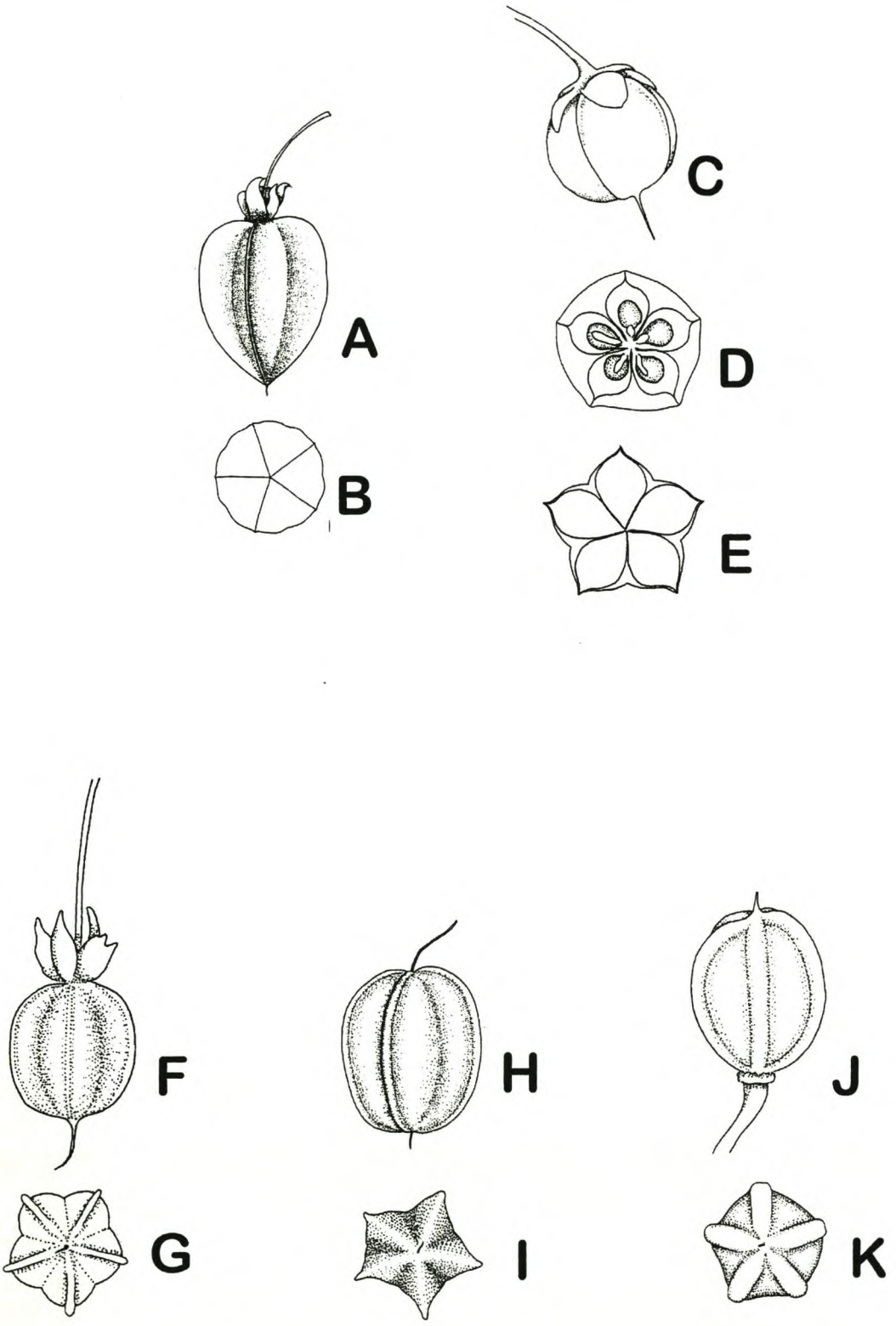


Figure 3.9. Fruits in subgenus *Zygophyllum* categorized as **ridged** (not to scale). A—B, *Z. pygmaeum, Van Zyl 3947*; C—E, *Z. spinosum, Van Zyl 3969*; F–G, *Z. porphyrocaule, Van Zyl 3613*; H—I, *Z. teretifolium, Van Zyl 4016*; J—K, *Z. foetidum, Van Zyl 4130*. A, side-view; B, top-view; C, side-view of succulent, fresh fruit; D, cross section of succulent, fresh fruit; E, cross section of dry fruit; F, side-view; G, top-view; H, side-view; I, top-view; J, side-view; K, top-view.

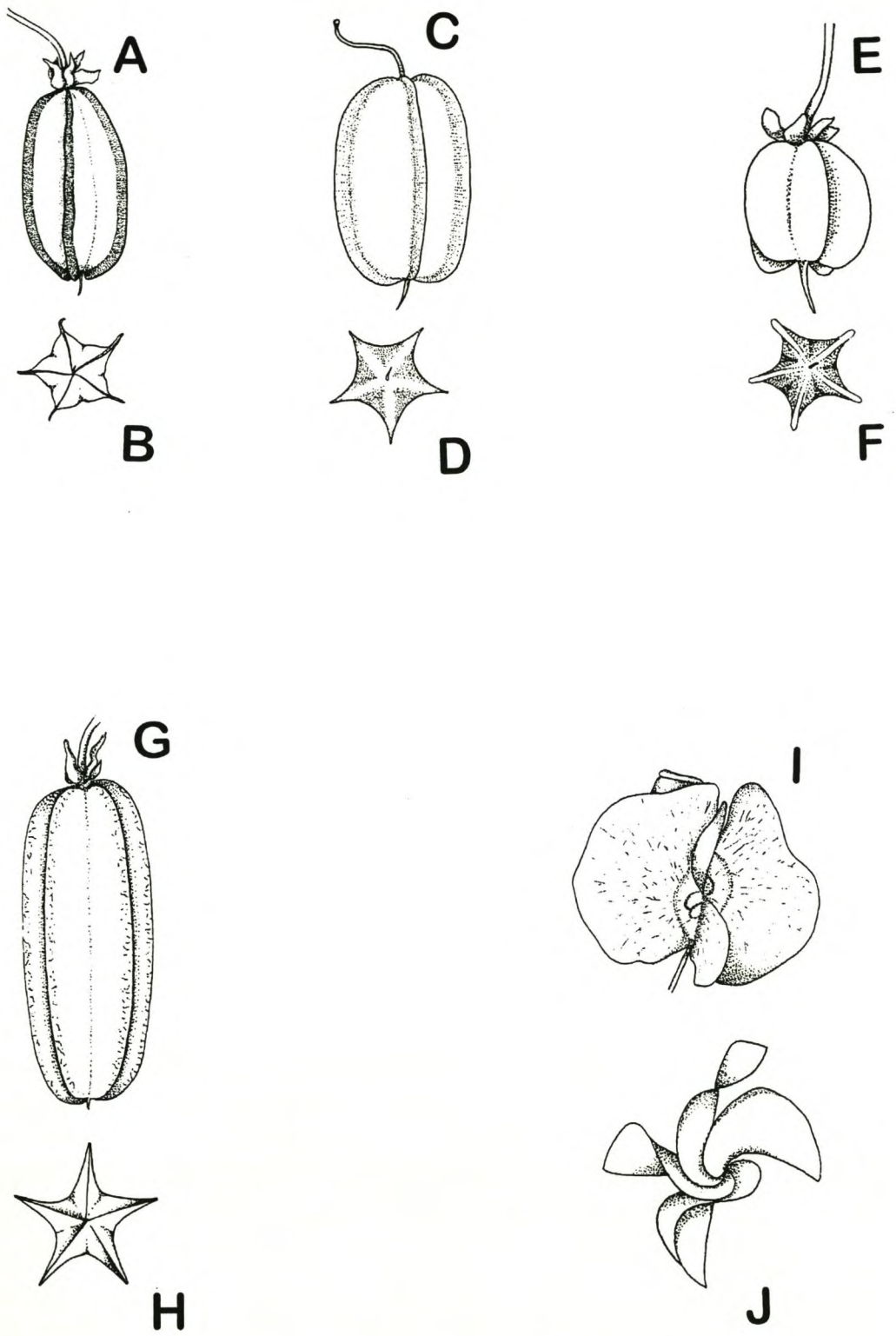


Figure 3.10. Fruits in subgenus *Zygophyllum* categorized as **winged** (not to scale). A—B, *Z. debile, Van Zyl 3943*; C—D, *Z. cordifolium, Van Zyl 3875*; E—F, *Z. lichtensteinianum, Van Zyl 3940*; G—H, *Z. macrocarpon, Van Zyl 3920*; I—J, *Z. morgsana, Van Zyl 3822.* A, side-view; B, top-view; C, side-view; D, top-view; E, side-view; F, top-view; G, side-view; H, top-view; I, side-view; J, top-view.

ridge on fruits can also be used to distinguish between some species. Table 3.5 summarizes the characters of fruits in the subgenus *Zygophyllum*.

Table 3.5. Fruit characters of subgenus *Zygophyllum*

SPECIES	FRUIT SHAPE WHEN DRY	FRUITS SHAPE WHEN FRESH, SUCCULENT	FRUIT SIZE IN MM
NOT RIDGED			
Z. maritimum	spherical or oblong, not ridged, sutures visible	—	12–15 x 10–13
Z. leucocladum	5-lobed, not ridged, exocarp thin and disintegrating	—	5–13 x 4
Z. cretaceum	5-lobed, not ridged, exocarp thin and disintegrating	—	3.5 x 5
Z. flexuosum	5-angled + wrinkled exocarp, subspherical	succulent, subspherical + 5 sutures visible	8–9 x 9–12
RIDGED			
Z. fusiforme	5-lobed + 5 ridges, ellipsoid	succulent, fusiform, + 5 sutures visible	15–21 x 5–9
Z. spinosum	5-lobed + 5 ridges spherical or oblong	succulent, spherical + 5 sutures visible	10–15 x 11–15
Z. fulvum	5-lobed + 5 ridges, oblong or subspherical	often succulent, oblong or subspherical + 5 sutures visible	8–20 x 9–14
Z. maculatum	5-lobed + 5 ridges, oblong	not succulent	12–13 x 7–8
Z. pygmaeum	5-lobed + 5 ridges, ovoid	not succulent	8–11 x 6–8
Z. rogersii	5-lobed + 5 ridges, spherical	not succulent	9–10 x 8
Z. botulifolium	5-lobed + 5 ridges, subspherical	not succulent	11 x 10
Z. divaricatum	5-lobed + 5 ridges, subspherical	not succulent	8–10 x 6–8
Z. schreiberanum	5-lobed + 5 ridges, subspherical, black when dry	not succulent	7–8 x 7–8
Z. incrustatum	5-lobed + 5 ridges, ovoid, black when dry	not succulent	9–10 x 6
Z. namaquanum	5-lobed + 5 ridges, subspherical or ovoid	not succulent	8–12 x 6–8
Z. fuscatum	5-lobed + 5 ridges, oblong	not succulent	12–14 x 11–12
Z. teretifolium	5-lobed + 5 ridges, oblong	not succulent	12–16 x 10 –13
Z. spitskopense	5-lobed + 5 ridges, oblong	not succulent	9–12 x 7–9
Z. sessilifolium	5-lobed + 5 ridges, oblong	not succulent	14 –15 x 9
Z. calcicola	5-lobed + 5 ridges, oblong	not succulent	10–13 x 10–13
Z. porphyrocaule	5-lobed + 5 ridges, oblong	not succulent	9–10 x 8–9

Z. swartbergense	5-lobed + 5 ridges, oblong	not succulent	11–15 x 10–12
Z. cuneifolium	5-lobed + 5 ridges, ovoid	not succulent	10–14 x 8–12
Z. pubescens	5-lobed + 5 ridges, oblong or subspherical	not succulent	8–9 x 5–8
Z. foetidum	5-lobed + 5 broad, flat, bony ridges, subspherical, usually bi-coloured	not succulent	8–12 x 6–10
Z. leptopetalum	5-lobed + 5 broad, flat ridges, subspherical, mono-chromatous	not succulent	7–13 x 7–12
WINGED			
Z. hirticaule	5-winged, oblong, wings 2 mm wide	not succulent	13–17 x 11–13
Z. debile	5-winged, oblong, wings 2 mm wide	not succulent	12–26 x 9–14
Z. macrocarpon	5-winged, prismatic, wings 5 mm wide	not succulent	25–43 x 15–20
Z. orbiculatum	5-winged, obovoid, wings 5 mm wide	not succulent	16–20 x 20–22
Z. cordifolium	5-winged, oblong, wings 2–5 mm wide	not succulent	10–34 x 9–18
Z. lichtensteinianum	5-winged, spherical, wings 2–3 mm wide	not succulent	6–7 x 6–8
Z. morgsana	4-winged, oblong or subspherical, wings 10–15 mm wide	not succulent	26–40 x 26–40

Subgenus *Agrophyllum*

The fruits of subgenus *Zygophyllum* are almost never ridged and can be categorized as either 5-lobed, 5-parted or 5-winged (Figure 3.11—13). These characters occur in combination with different shapes of the fruits which could be spherical, oblong, obovoid, ellipsoid, rhomboid, depressed ovoid, prismatic and turbinoid. Succulency is common in this subgenus and is found in almost 50% of its species. The near absence of ridges on the fruits of species in subgenus *Agrophyllum* is of taxonomic value at subgeneric level. Table 3.6 summarizes the characters of fruits in the subgenus *Agrophyllum*.

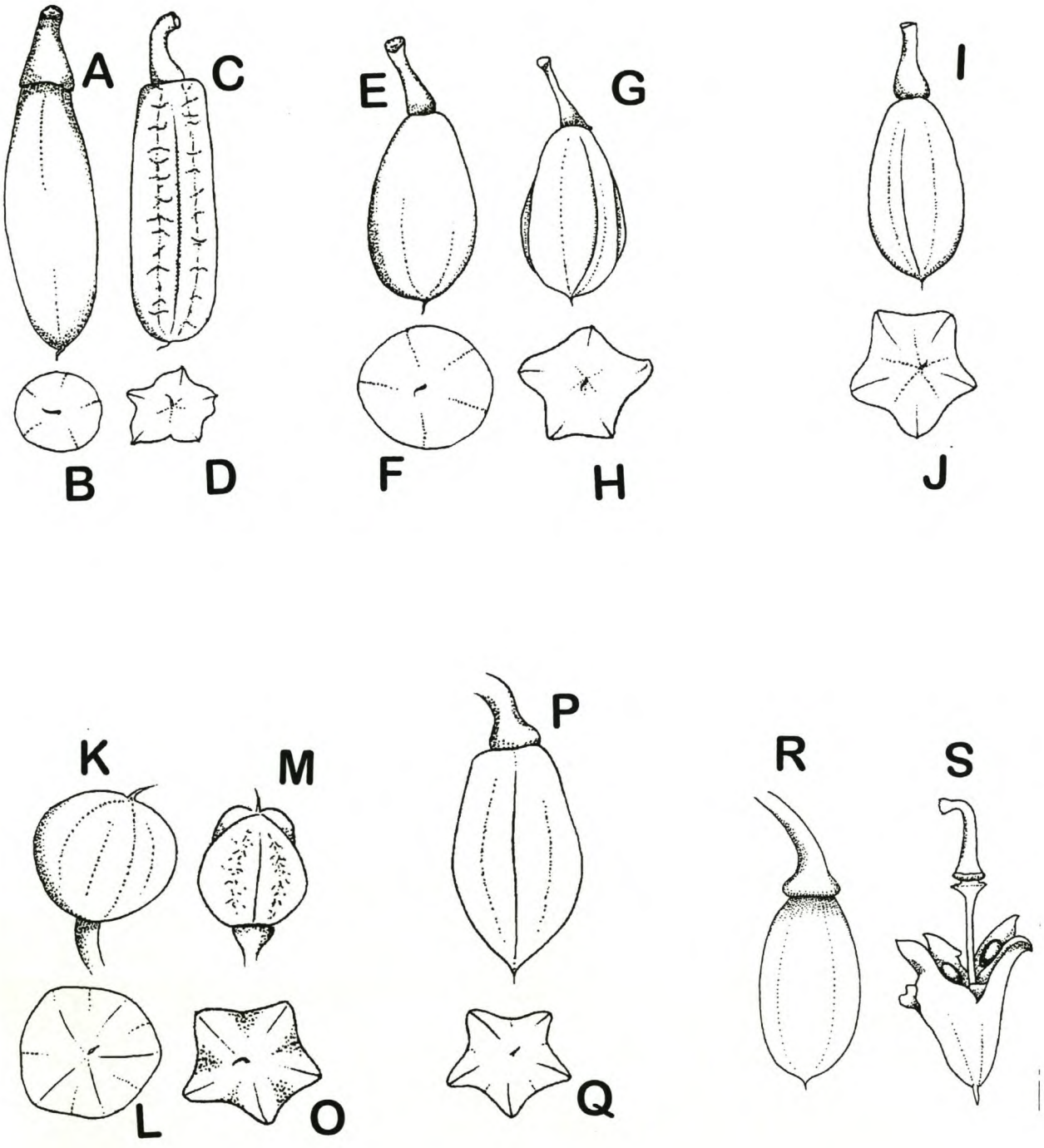


Figure 3.11. Fruits in subgenus Agrophyllum categorized as **5-lobed** (not to scale). A—D, *Z. applanatum, Van Zyl 3881*; E—H, *Z. segmentatum, Van Zyl 4473*; I—J, *Z. cylindrifolium, Van Zyl 3795*; K—O, *Z. retrofractum, Van Zyl 4580*; P—Q, *Z. tenue, Van Zyl 3850*; R—S, Z. longicapsulare, Van Zyl 4350. A—B, side- and top-view of fresh, succulent fruit; C—D, side- and top-view of dry fruit; E—F, side- and top-view of fresh, succulent fruit; G—H, side- and top-view of dry fruit; I—J, side- and top-view of dry fruit; K—L, side- and top-view of fresh, succulent fruit; M—O, side- and top-view of dry fruit; P—Q, side- and top-view of dry fruit; R, side-view of fresh, succulent fruit; S, side-view of mature, disintegrating fruit.

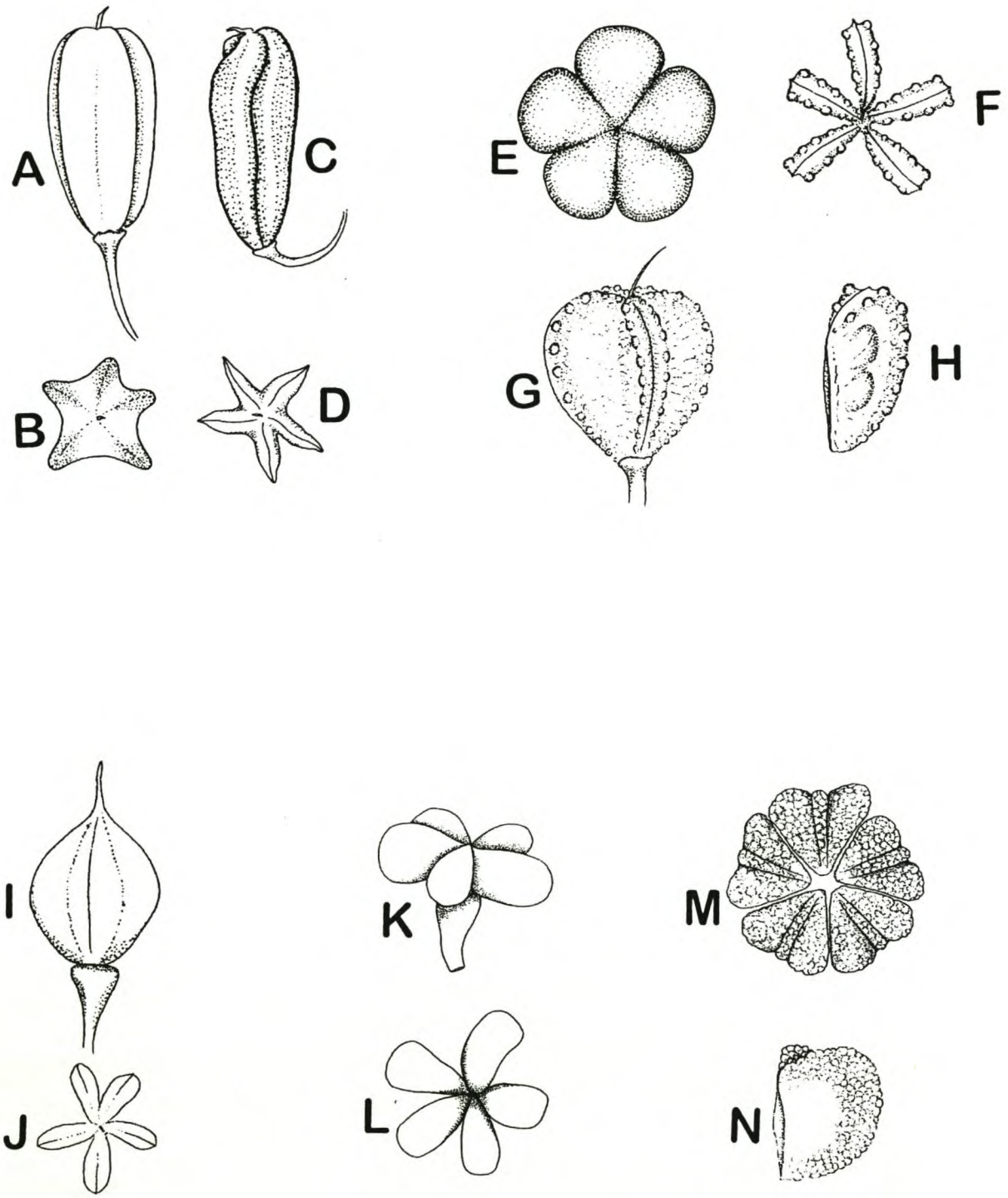


Figure 3.12. Fruits in subgenus *Agrophyllum* categorized as **5-parted** (not to scale). A—D, *Z. prismatocarpum, Van Zyl 4471*; E—H, *Z. simplex, Van Zyl 3825*; I—J, *Z. decumbens var. decumbens, Van Zyl 4317*; K—L, *Z. clavatum, Van Zyl 3790*; M—N, *Z. spongiosum, Van Zyl 3825*. A—B, side- and top view of fresh, succulent fruit; C—D, side- and top-view of dry fruit; E, top-view of fresh, succulent fruit; F—G, top-and side-view of dry fruit; H, side-view of dry mericarp; I—J, side- and top-view of dry fruit; K—L, side- and top-view of dry fruit; M, top-view of dry fruit; N, side-view of mericarp.

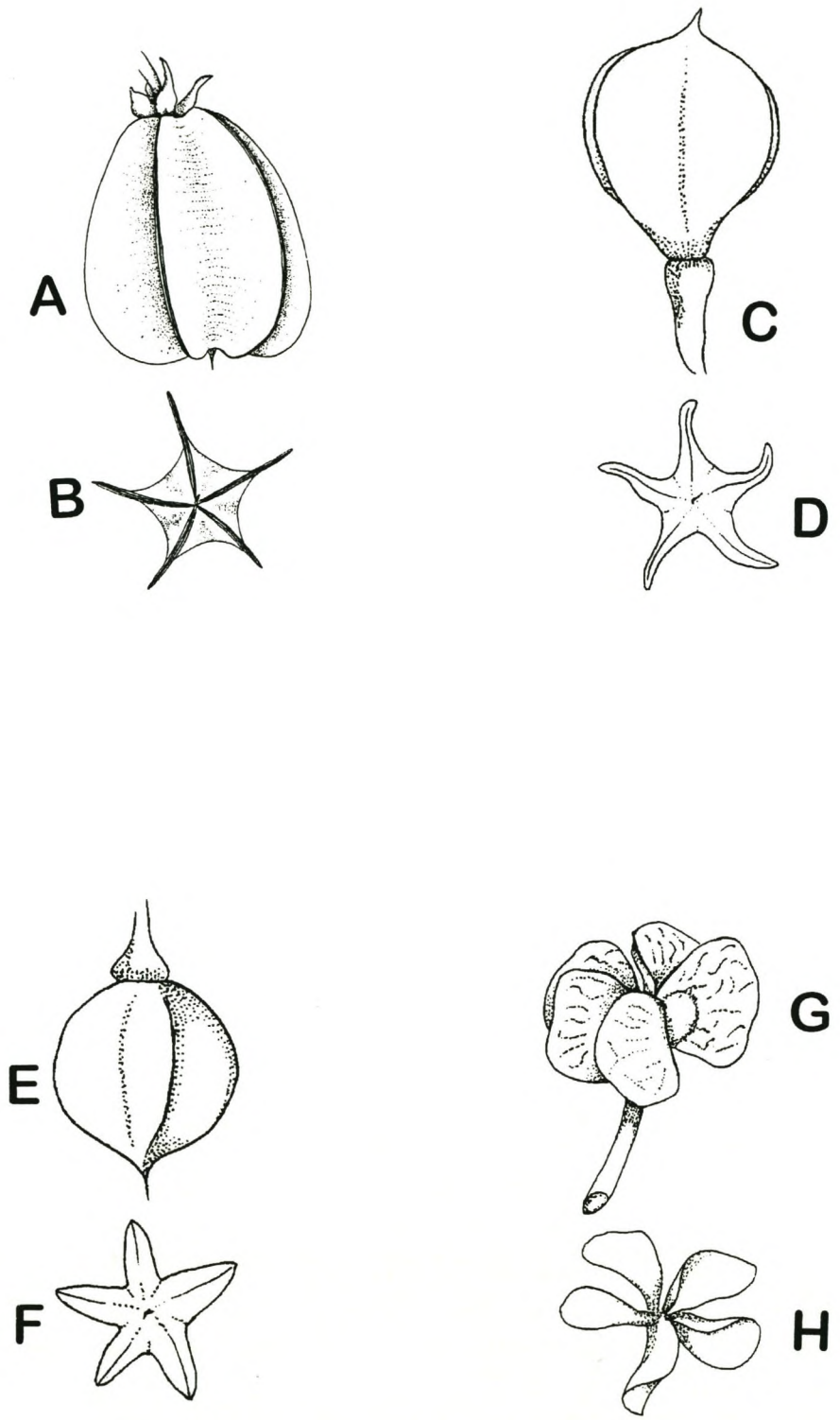


Figure 3.13. Fruits in subgenus *Agrophyllum* categorized as **5-winged** (not to scale). A—B, *Z. stapffii, Van Zyl 3791*; C—D, *Z. turbinatum, Van Zyl 4516*; E—F, *Z. chrysopteron, Van Zyl 4553*; G—H, *Z. microcarpum, Van Zyl 4532*. A, side-view; B, top-view; C, side-view; D, top-view; E, side-view; F, top-view; G, side-view; H, top-view.

Table 3.6. Fruit characters in subgenus *Agrophyllum*

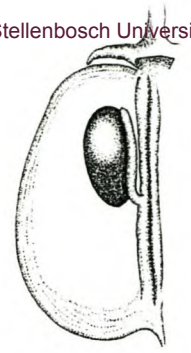
SPECIES	FRUIT SHAPE WHEN DRY	FRUIT SHAPE WHEN FRESH, SUCCULENT	FRUIT SIZE IN MM
5-LOBED			
Z. applanatum	5-lobed, oblong	succulent, cylindri-cal+ sutures visible	10–12 x 3.5–4
Z. cylindrifolium	5-lobed, obovoid	succulent, obovoid + sutures visible	7–8 x 3.5–4
Z. segmentatum	5-lobed, obovoid	succulent, obovoid + sutures visible	5.5–6 x 3.5
Z. tenue	5-lobed, obovoid	?	5–7 x 2.5–3.5
Z. retrofractum	5-lobed, ellipsoid, rhomboid	succulent, subsphe-roid, ellipsoid	3–5 x 3–5
Z. longicapsulare	5-lobed, oblong	succulent, cylindrical, spherical + sutures visible	8–14 x 4–7
Z. giessii	5-lobed, oblong	succulent, cylindrical or ellipsoid + sutures visible	7–10 x 3–4
5-PARTED			
Z. decumbens	5-parted, rhomboid or turbinoid		3–4 x 3–4.5
Z. clavatum	5-parted, depressed ovoid		1.2–2 x 4–6
Z. simplex	5-parted, obovoid, oblong	succulent, sphaerical,obovoid, obcordate	2.5–5.5 x 2–3
Z. spongiosum	5-parted, spherical		1.5–1.8 x 2.5–3.5
Z. inflatum	5-parted, obovoid		4 x 4
Z. pterocaule	5-parted, prismatic	succulent, oblong, 5-lobed	9 x 6
Z. patenticaule	5-parted, prismatic	succculent, oblong	8–10 x 3–4
Z. prismatocarpum	5-parted, prismatic	succulent, ovoid, oblong	9–11 x 4–5
5-WINGED			
Z. chrysopteron	5-winged, subspherical		3–4 x 3.5–4
Z. turbinatum	5-winged, turbinoid		4–5 x 4–5
Z. microcarpum	5-winged, oblong		1–13 x 7–8
Z. longistipulatum	5-winged, depressed oblong		2–3 x 7.5
Z. rigidum	5-winged, oblong		12–15 x 5–7
Z. stapffii	5-winged, obovoid		17–21 x 14–16

When comparing Tables 3.1 and 3.5 it is clear that the species arrangement according to leaf characters differs from an arrangement according to fruit characters. This confirms the taxonomic importance of these characters both on species level but also in grouping species together when subdividing both subgenera.

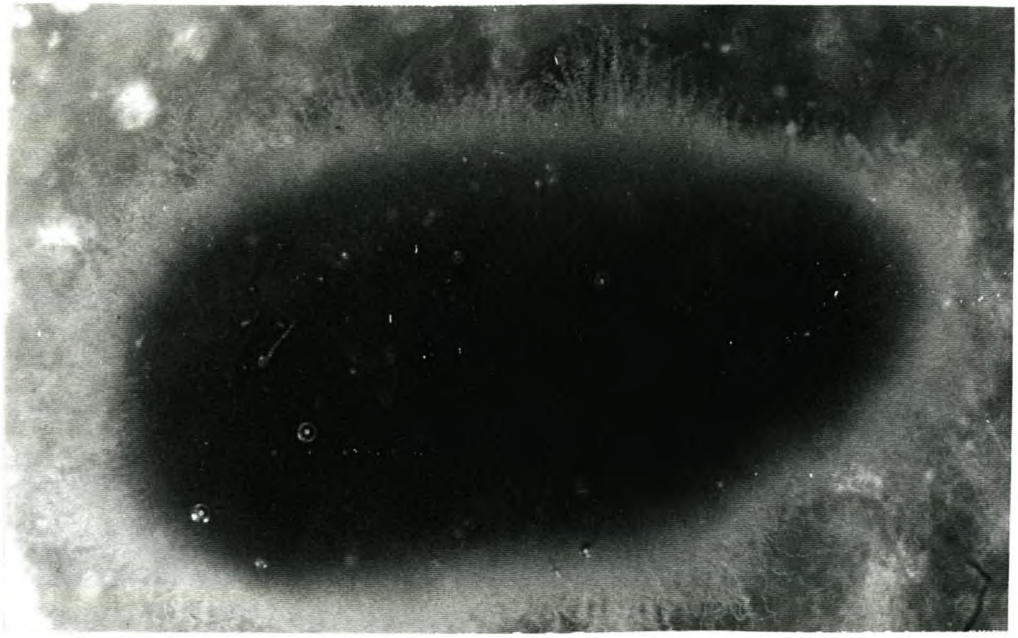
Seeds

The majority of seeds found in subgenus *Zygophyllum* are almost oblong in **shape,** round in cross section, smooth and shiny, dark brown or nearly black and display a prominent white aril (Figure 3.14.A). Bond & Slingsby (1983) described the dispersal of the seeds in this subgenus as myrmecochorous which is dispersal by ants. This is effected through the aril on the seed, which is chemically attractive to ants which collect the seed and consume only the aril. The **number** of mature seeds per locule is variable and can be as high as 16, as found in *Z. macrocarpon*, or one only, as found in *Z. spinosum* and its allies. This variation also occurs within a species and is probably caused by the abortion of some ovules due to non-pollination or changes in climatological conditions. The abortive ovules are visible within the locules as small, white threads attached to the placenta. Seed number is not considered a stable character and is of little taxonomic value. The **size** of the seeds varies amongst species. The smallest seeds, 3 x 1.5 mm in size, are those of *Z. cretaceum,* which also display vague lateral ridges. The largest seeds are those of *Z. cuneifolium,* which are 6–7 x 3 mm in size. Although the fruits of *Z. macrocarpon* are almost the largest in *Zygophyllum* and occur in combination with the largest number of seeds per locule (Table 3.7), no such correlation exists in any other species. The large fruits of *Z. spinosum* (10–15 x 11–15 mm in size) usually contain but one seed per locule. All properly matured seeds of subgenus *Zygophyllum* produce copious amounts of mucilage when immersed in water. The mucilage is of a structured type, containing long, spiral inclusions of a uniform width (Engler 1931, Hedge 1970, Gruber 1974; Figure 3.14.B—C). The type of mucilage produced is stable and of taxonomic importance at subgeneric level.

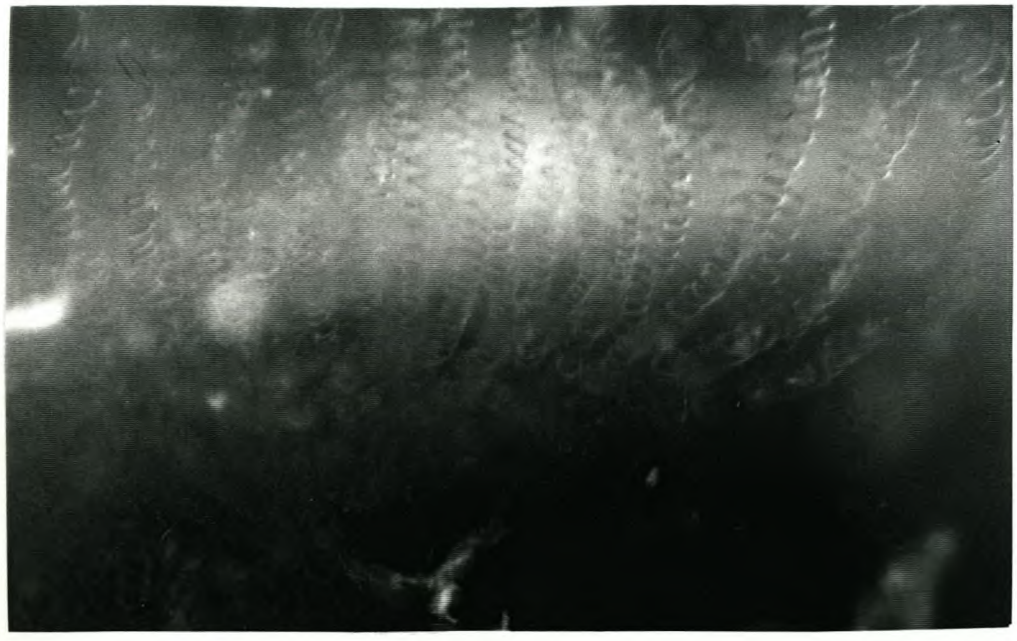
The majority of seeds found in the subgenus *Agrophyllum* are pyriform in **shape** and have two, flat sides. The seeds of species in § *Alata* and § *Grandifolia* are even



A



B



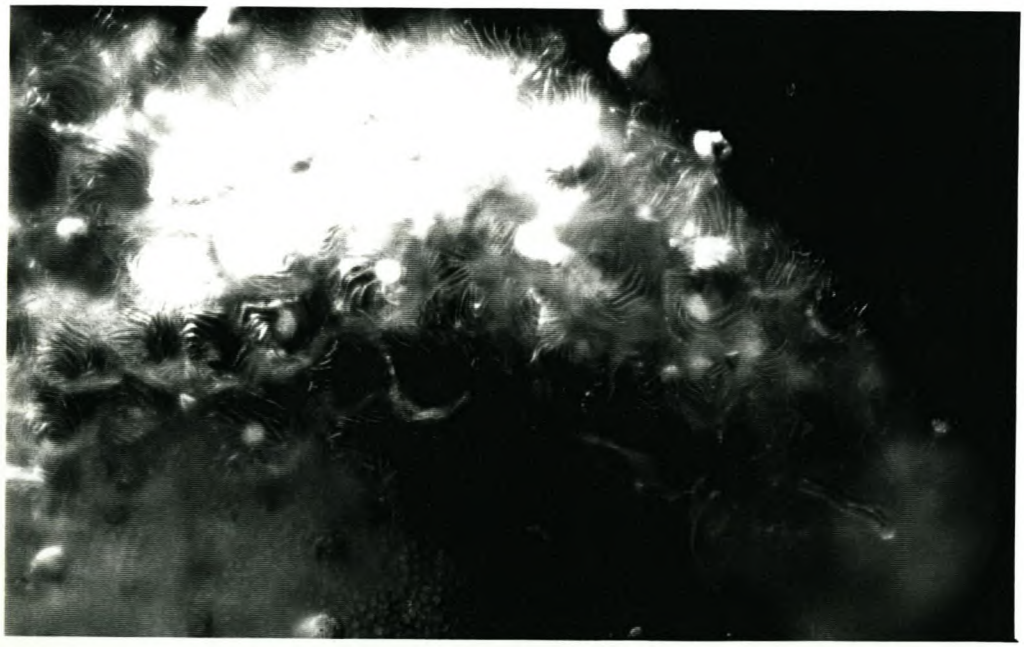
C

Figure 3.14. A, longitudinal section through a fruit in subgenus *Zygophyllum* displaying an oblong seed with a prominent, white aril; B—C, *Z. cuneifolium, Van Zyl 3959*; B, wet seed displaying a thick layer of mucilage; C, close-up of long uniformly wide spiral inclusions seen in B.

flatter, and described as compressed pyriform in shape for the sake of conformity, although the term pyriform refers to a three dimensional, pear shaped structure. The seeds in this subgenus are brownish and have a grainy texture and are attached with long, thin funicles, which are visible in immature seeds but absent in mature seeds (Figure 3.15.A). *Z. stapffii* is an exception and displays a short, thick funicle. In this subgenus the absence of an aril is probably evidence of a different dispersal strategy, which could be anemochory. The shape of seeds and the presence of a funicle are stable characters and considered of diagnostic value at subgeneric level. The **number** of mature seeds per locule varies amongst and within species. The highest number is about 12 seeds per locule as found in *Z. giessii,* and the lowest is one only as found in *Z. longistipulatum*. The variation in the number of mature, fully developed seeds per locule found within species is probably caused by the abortion of ovules. The abortive ovules are visible within the locules as small, white threads attached to the placenta. Seed number is not considered a stable character and is of little taxonomic value. The **size** of mature seeds varies amongst species, but is stable within a species. The smallest seeds are those of *Z. simplex* and its allies ranging from 0.8–1.0 x 0.3–0.5 mm in size and which are also farinaceous. *Z. stapffii* has the largest seeds which are usually 5 x 3 mm in size. The largest fruits in this subgenus are those of *Z. rigidum,* which are 12–15 x 5–7 mm in size and have 1–3 seeds per locule. Although these fruits are rather large, the seeds are quite small, only 2.3–2.8 x 1.5–1.8 mm in size. No correlation exists between fruit size and seed size. All the seeds of subgenus *Agrophyllum* are smaller than those in subgenus *Zygophyllum* (Table 3.7). When immersed in water, the seeds of most species in subgenus *Agrophyllum* produce copious amounts of mucilage which is of a structured type, containing short, spiral inclusions, the upper part of which seems to unravel, resembling the shape of a wine glass in side-view (Figure 3.15.B—C). These structures form a distinct pitted pattern on the testa, resulting in a grainy surface. Of interest here are the optical properties displayed by the seeds in this subgenus, which become transparent when wet with the embryo clearly visible within. The mucilage produced by the species in § *Annua* is unstructured and jelly-like and contains no inclusions. The type of mucilage produced is stable and considered of taxonomic importance at a subgeneric level

A

B



C

Figure 3.15. A, longitudinal section through a fruit in subgenus *Agrophyllum* displaying pyriform seeds with long funicles; B—C, *Z. stapffii*, *Van Zyl 3791*; B, mucus on wet seed, illustrating the short, spiral inclusions that seem to unravel at apex, looking like a wineglass in side-view; C, top-view of spiral inclusions seen in B.

and in § *Annua* also useful in the delimitation of the section. Table 3.7 summarizes the seed characters of *Zygophyllum* species.

Table 3.7. Seed characters of *Zygophyllum* species

SECTION	SPECIES	SEED SHAPE	SEEDS / LOCULE	SEED SIZE IN MM
SUBGENUS AGROPHYLLUM				
Annua	Z. simplex	pyriform, farinous + funicle	2–9	0.8–1.0 x 0.3–0.5 **(smallest)**
	Z. spongiosum	pyriform, farinous + funicle	1–2	0.8–1.3 x 0.5
	Z. inflatum	pyriform, farinous + funicle	2–4	0.8 x 0.5
Prismatica	Z. prismatocarpum	pyriform + funicle	10–12	1.5 x 1.0
	Z. patenticaule	pyriform + funicle	8–10	1.5 x 1.0
	Z. pterocaule	pyriform + funicle	8–10	1.0 x 0.5
Bipartita	Z. applanatum	pyriform + funicle	4–8	1.5 x 0.6
	Z. clavatum	pyriform + funicle	0–2	1.5–1.8 x 0.7–1.0
	Z. cylindrifolium	pyriform + funicle	4–12	1.5 x 0.6
	Z. segmentatum	pyriform + funicle	4–7	1.5 x 0.5
	Z. tenue	pyriform + funicle	2–4	1.8 x 0.8
	Z. chrysopteron	pyriform + funicle	1–2	2.0 x 1.5
	Z. retrofractum	pyriform + funicle	1–2	2.0–2.5 x 1.0–1.5
	Z. turbinatum	pyriform + funicle	1–2	2.5 x 1.5
	Z. decumbens	pyriform + funicle	8–10	1.0 x 0.5
subs. *Alata*	Z. microcarpum	pyriform compressed + funicle	1–2	3.0–4.0 x 2.0–2.5
	Z. rigidum	pyriform,compressed + funicle	1–3	2.3–2.8 x 1.5–1.8
	Z. longistipulatum	pyriform compressed + funicle	1	1.5–2.0 x 1.0–1.5
Cinerea	Z. longicapsulare	pyriform + funicle	5–9	2.0 x 1.0
	Z. giessii	pyriform + funicle	5–15	?
Grandifolia	Z. stapffii	subpyriform, compressed + short, thick funicle	1–3	5.0–3.0

SUBGENUS ZYGOPHYLLUM				
Paradoxa	Z. cordifolium	oblong + aril	1–4	5.0 x 2.5
	Z. fusiforme	oblong + aril	1–4	4.0 x 2.0
	Z. orbiculatum	?	?	?
Capensia	Z. teretifolium	oblong + aril	1–4	5.0–6.0x 2.0–3.0
	Z. botulifolium	oblong + aril	1	4.02.5
	Z. spinosum	oblong + aril	1	6.0–7.0 x 2.5–3.0
	Z. pygmaeum	oblong + aril	1	3.0 x 2.0
	Z. rogersii	oblong + aril	1	4.0 x 2.0
	Z. divaricatum	oblong + aril	1–2	?
	Z. namaquanum	oblong + aril	1	?
	Z. sessilifolium	oblong + aril	1	4.5–5.5 x 2.0–2.5
	Z. spitskopense	oblong + aril	1	4.0 x 2.0
	Z. cuneifolium	oblong + aril	1–2	6.0–7.0 x 3.0
	Z. hirticaule	oblong + aril	1–3	4.0 x 2.0
	Z. calcicola	oblong + aril	1–3	4.0 x 2.5
	Z. fulvum	oblong + aril	1–2	3.5 x 2.0–2.5
	Z. porphyrocaule	oblong + aril	1–2	3.5–4.0 x 1.5–2.0
	Z. swartbergense	oblong + aril	1–4	4.5 x 2.0
	Z. fuscatum	oblong + aril	1–3	4.0 x 2.0
	Z. flexuosum	roundish + aril	1	3.0–3.5 x 2.5–3.0
	Z. lichtensteinianum	oblong + aril	1–3	3.0–3.5 x 1.5–2.0
	Z. incrustatum	oblong + aril	1	5.0 x 2.0
	Z. maritimum	oblong + aril	1–4	4.0–5.0 x 2.5–3.0
	Z. debile	oblong + aril	4–7	4.0 x 1.5–2.0
	Z. cretaceum	oblong + lateral grooves + aril	1–2	3.0 x 1.5
	Z. foetidum	oblong + aril	1–5	4.0–5.0 x 2.0–3.0
	Z. macrocarpon	oblong + aril	10–16	4.0–5.0 x 2.0–3.0
	Z. maculatum	oblong + aril	2–3	4.0 x 2.0
	Z. schreiberanum	oblong + aril	1–2	4.0 x 1.8
	Z. leptopetalum	oblong + aril	1–2	5.5 x 2.3
	Z. pubescens	oblong + aril	1–2	4.0 x 2.0
	Z. leucocladum	oblong + aril	1–2	3.5 x 2.0
Morgsana	Z. morgsana	oblong + aril	1–4	5.0–5.5 x 3.0

CHAPTER 4

GEOGRAPHICAL DISTRIBUTION OF *ZYGOPHYLLUM* IN SOUTHERN AFRICA

Within the southern African region, which includes Angola, Botswana, Lesotho, Namibia, South Africa and Swaziland, most *Zygophyllum* species are typically found in arid to semi-arid and saline areas occurring along the western and central part of the subcontinent, although some species do occur in less harsh conditions along the south coast. The southwest African region is of special importance to the Zygophyllaceae, with special reference to the genus *Zygophyllum* in southern Africa (El Hadidi 1978, Van Zyl & Marais 1999) and seven genera and 46 species occur in this area (Goldblatt 1978; Gibbs Russell 1985). Numerous phytogeographical classifications for this area exist, eg. Acocks (1953), Werger (1978), Jürgens (1991), Irish (1994), Low & Rebelo (1996), Cowling & Hilton-Taylor (1997). The Karoo-Namib region, as defined by Cowling & Hilton-Taylor (1997) is of importance in the geographical distribution of *Zygophyllum.* For the purpose of this study, the classification of Low & Rebelo (1996) which further refines the Karoo-Namib region of South Africa into Nama Karoo and Succulent Karoo, was followed. Additional data for Namibia was taken from Irish (1994; Figure 4.1). Eight biomes are recognized for the southern African region and listed in the sequence given by Low & Rebelo (1996): Forest Biome, Thicket Biome, Savanna Biome, Grassland Biome, Nama Karoo Biome, Succulent Karoo Biome and Fynbos Biome, and added to this the Desert Biome of Namibia (Irish 1994). *Zygophyllum* species are found in all these biomes except in the Forest Biome. The number of *Zygophyllum* species found in each biome differs considerably and is the highest in the arid and semi-arid Biomes (Table 4.1).

Table 4.1. *Zygophyllum* species represented in the different Biomes of southern Africa.

Biome	Number of Zyg. species	% of total Zyg. species	Number of Zyg. species restricted to the biome
Forest	—	—	—
Thicket	10	18%	2
Savanna	8	15%	—
Grassland	2	4%	—
Nama Karoo	20	37%	4
Succulent Karoo	32	59%	12
Fynbos	11	20%	2
Desert	11	20%	2

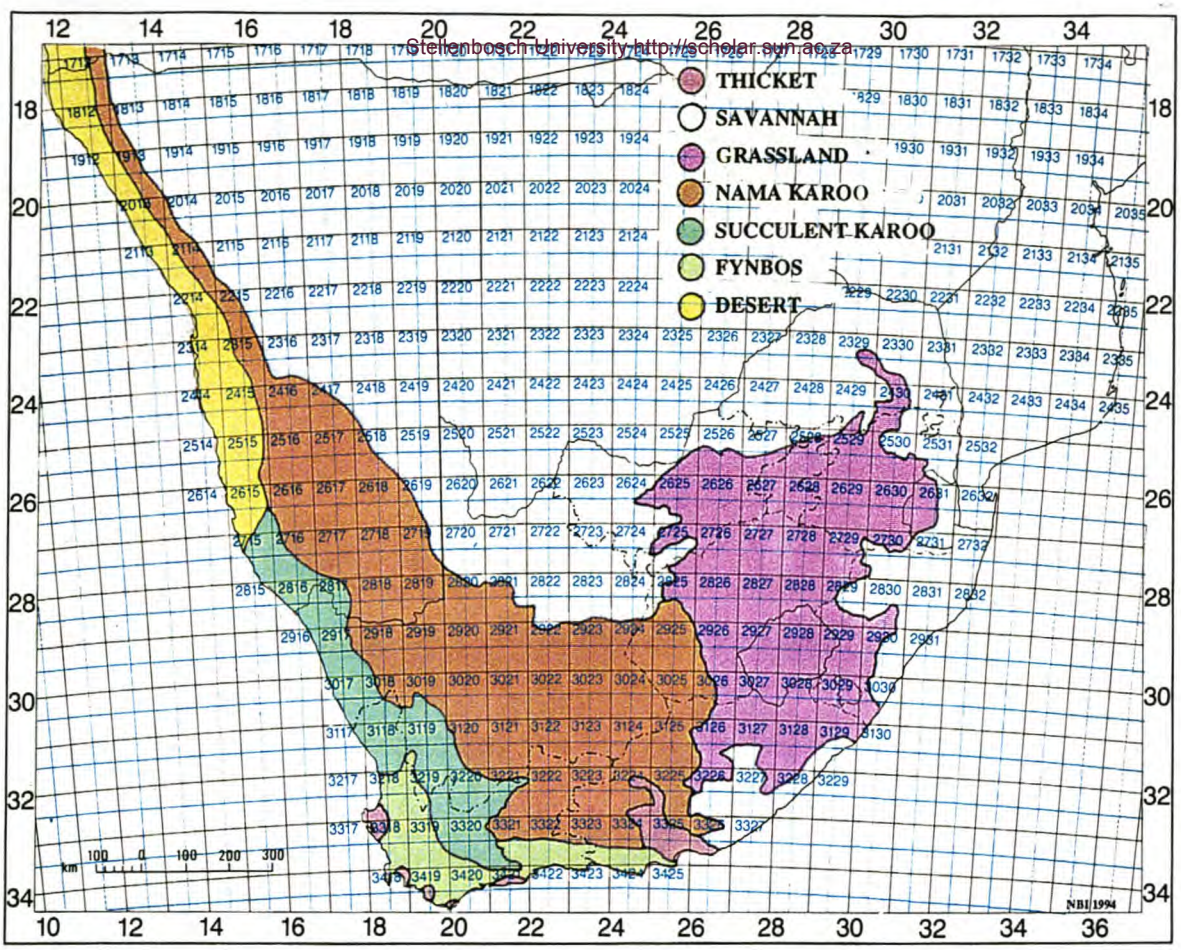


Figure 4.1 Vegetation of southern Africa divided into various **Biomes.**

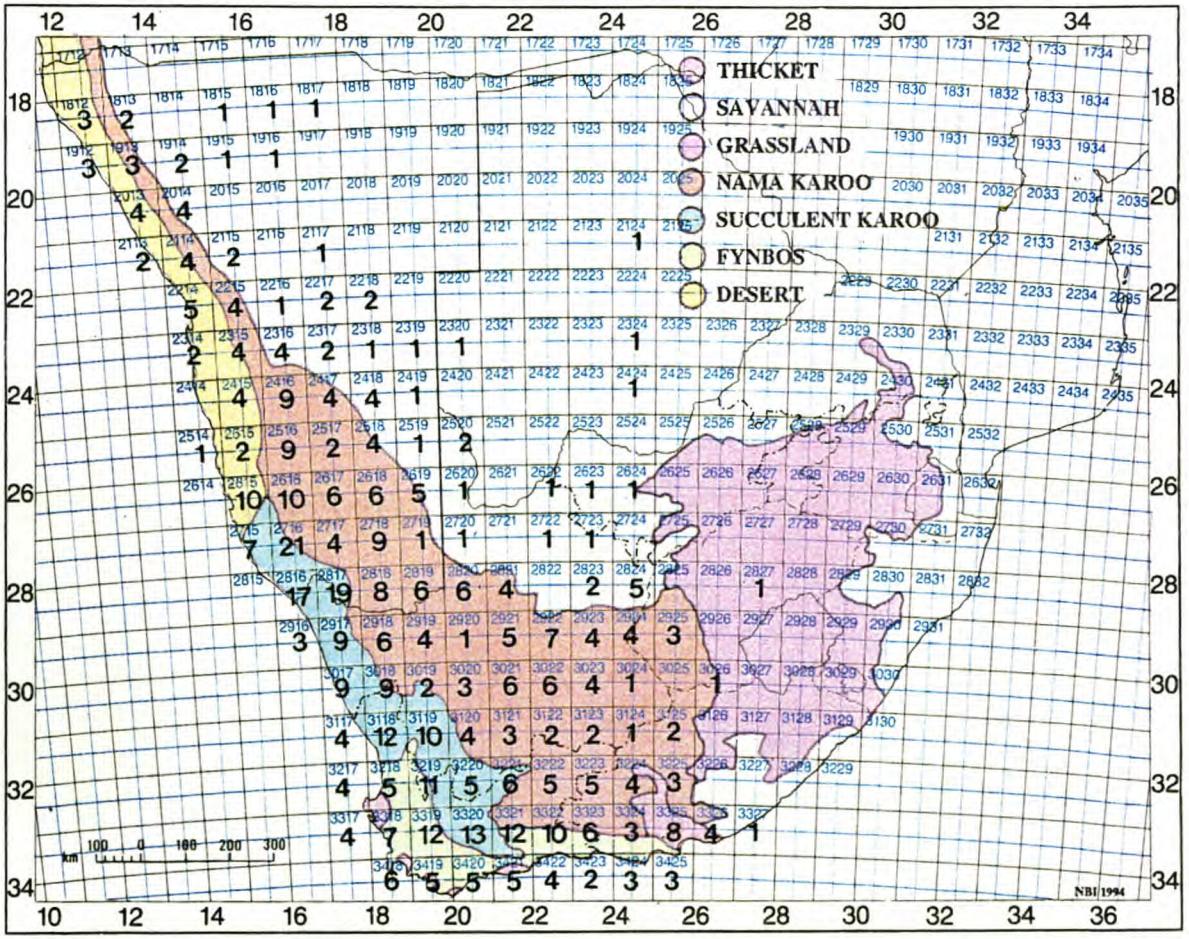


Figure 4.2. Species diversity of the **genus *Zygophyllum*** in the biomes of southern Africa.

Thicket Biome

According to Lubke (1996), there is no formal "Thicket Biome" recognized in any scientific literature. It was felt though, that the vegetation replacing forest, does not fit in with the "Forest" type as it lacks the height and the many different strata below the canopy. It could not be placed under "Savanna" either, because of the absence of grasses. Thicket is a closed shrubland or low forest area dominated by small, evergreen, fine-leafed or succulent trees, shrubs or vines (Lubke, 1996). It occurs in small pockets along the South African coast line as well as further inland towards the eastern side of the country (Figure 4.1). Stem spines are found on many species in this Biome. Thicket is often impenetrable and cannot be divided into strata. Only a few herbaceous species are present. It contains a few endemics, most of which are succulents. Rainfall is from 250—1500 mm per annum and occurs throughout the year, in winter in the Western Cape, in spring and autumn in the Southern Cape and mostly in summer in the northern part of its range (Table 4.3) (page 41). Valley mists are common and frosts rare. Temperatures range from moderate to extremes above 40°C. Substrates are dune sands, or lime-rich sandy clays or loam.

The genus *Zygophyllum* is represented in the Thicket Biome by ten out of 54 *Zygophyllum* species. Only two *Zygophyllum* species are restricted to the Thicket Biome and are indicated in bold print in Table 4.2. The Thicket Biome shares three *Zygophyllum* species with the adjacent Fynbos Biome, four with the Succulent Karoo Biome and only one with the Nama Karoo Biome. The diversity map of *Zygophyllum* reveals a secondary diversity centre (3325 Port Elizabeth; Figure 4.3) for the subgenus *Zygophyllum*, where eight species are recorded in the Thicket Biome. This area corresponds to the Albany centre of endemism in which ›600 endemics are found (Van Wyk & Smith, in press). *Z. divaricatum* is the only *Zygophyllum* species restricted to this centre of endemism.

Savanna Biome

The Savanna Biome is the largest biome in southern Africa and occupies 46% of its area (Van Rooyen & Bredenkamp 1996). It occurs in the low-lying areas below the eastern escarpment, in the Kalahari region of southern Africa as well as in Botswana, Namibia and Zimbabwe (Figure 4.1). This Biome is characterized by a

Thicket Biome	Savanna Biome	Grassland Biome	Nama Karoo Biome	Succulent Karoo Biome	Fynbos Biome	Desert Biome
1 Z. calcicola	1 Z. incrustatum	1 Z. incrustatum	1 Z. chrysopteron	1 **Z. applanatum**	1. Z. calcicola	1 Z. clavatum
2 Z. cordifolium	2 Z. leucocladum	2 Z. simplex	2 Z. cretaceum	2 **Z. botulifolium**	2. Z. debile	2 Z. cordifolium
3 Z. debile	3 Z. lichtenstein.		3 Z. cylindrifolium	3 Z. chrysopteron	3. Z. fulvum	3 Z. cylindrifolium
4 **Z. divaricatum**	4 Z. microcarpum		4 **Z. decumbens**	4 Z. clavatum	4. Z. fuscatum	4 Z. inflatum
5 Z. flexuosum	5 Z. pubescens		5 **Z. giessii**	5 Z. cordifolium	5. Z. morgsana	5 Z. longicapsulare
6 Z. foetidum	6 Z. tenue		6 Z. incrustatum	6 Z. cretaceum	6. Z. namaquanum	6 Z. morgsana
7 Z. fulvum	7 Z. simplex		7 Z. inflatum	7 **Z. cuneifolium**	7. Z. porphyrocaule	7 **Z. orbiculatum**
8 Z. lichtenstein.	8 Z. spongiosum		8 Z. leucocladum	8 Z. debile	8. Z. pygmaeum	8 Z. prismatocarpum
9 **Z. maritimum**			9 Z. lichtenstein.	9 Z. foetidum	9. Z. sessilifolium	9 Z. simplex
10 Z. morgsana			10 Z. longicapsulare	10 **Z. fusiforme**	10. **Z. spitskopense**	10 Z. spongiosum
			11 **Z. longistipulatum**	11 **Z. hirticaule**	11. **Z. swartbergense**	11 **Z. stapffii**
			12 Z. macrocarpon	12 **Z. leptopetalum**		
			13 Z. microcarpum	13 Z. longicapsulare		
			14 Z. pubescens	14 Z. lichtenstein.		
			15 Z. retrofractum	15 **Z. maculatum**		
			16 **Z. rigidum**	16 Z. macrocarpon		
			17 Z. simplex	17 Z. microcarpum		
			18 Z. spongiosum	18 Z. morgsana		
			19 Z. tenue	19 Z. namaquanum		
			20 Z. turbinatum	20 **Z. patenticaule**		
				21 Z. porphyrocaule		
				22 Z. prismatocarp.		
				23 **Z. pterocaule**		
				24 Z. pubescens		
				25 Z. pygmaeum		
				26 Z. retrofractum		
				27 **Z. schreiberanum**		
				28 **Z. segmentatum**		
				29 Z. simplex		
				30 Z. spinosum		
				31 **Z. teretifolium**		
				32 Z. turbinatum		

Table 4.2. *Zygophyllum* species as they occur in the Biomes of southern Africa, those restricted to a biome are in **bold.**

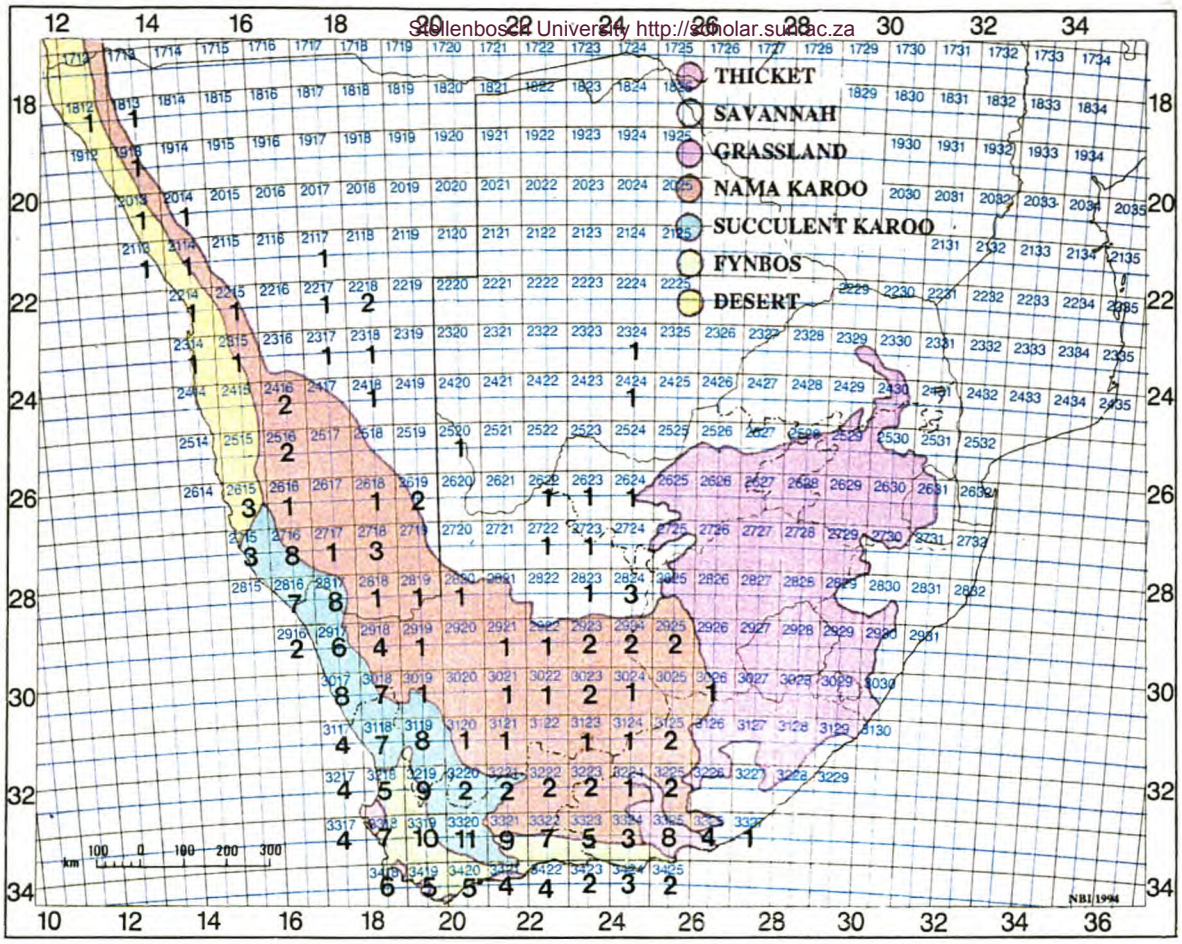


Figure 4.3. Species diversity of **subgenus *Zygophyllum*** in the biomes of southern Africa.

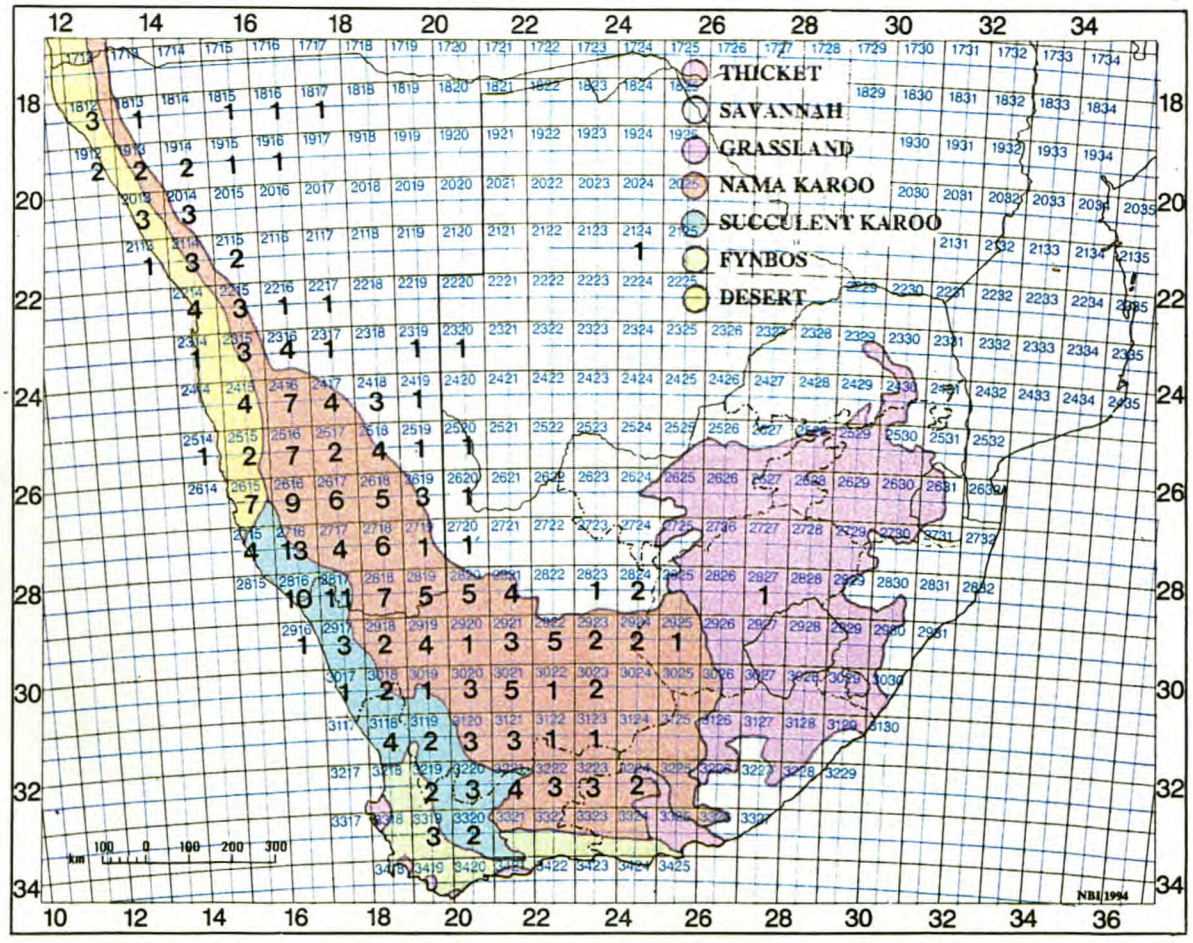


Figure 4.4. Species diversity of **subgenus *Agrophyllum*** in the biomes of southern Africa.

grassy ground layer accompanied by an upper layer of woody plants or trees. Its altitude ranges from 0—2000 m above sea level and rainfall ranges between 235–1000 mm per year falling mainly during summer months (Table 4.3). **Frosts and fires are common** and most species are adapted to survive fires by resprouting from stem bases (including some *Zygophyllum* species). Most of this area is utilized for grazing purposes by cattle or game farmers, but its conservation is of a high standard due to the presence of several game parks. Most *Zygophyllum* species occurring in this Biome are widespread species also found in other Biomes. The Savanna Biome shares seven of its eight *Zygophyllum* species with the Nama Karoo and four with the Succulent Karoo Biomes respectively (Table 4.2).
This is not a very important Biome for *Zygophyllum,* since only eight of its 54 species occur here. It is probable that *Zygophyllum* speciation in this biome is of less importance when compared to the adaptability displayed by of most of the *Zygophyllum* species occurring here (none restricted to this Biome). The Griqualand West centre of endemism lies within the Savanna Biome (Kalahari Mountain Bushveld and Kalahari Plateau Bushveld). About 1800 species occur in this centre, including › 40 endemics (Van Wyk & Smith in press). Although *Z. pubescens* occurs within this centre, it is a widespread species and not restricted to this centre.

Grassland Biome

This Biome occurs on the high, central plateau of southern Africa as well as the inland areas of Kwazulu Natal at altitudes ranging from near sea level to 2850 m high (Figure 4.1). **Grasslands are dominated by a single layer of grasses** and trees are absent. **Rainfall occurs during summer months with severe frosts during winter** (Table 4.3). Frosts, fires and grazing keep the grasses dominant. This is not an important Biome for the genus *Zygophyllum,* as it is represented by only two species, namely *Z. simplex* and *Z. incrustatum* (Table 4.2). The low number of *Zygophyllum* species is an indication of little or no forces present to promote speciation of *Zygophyllum* in this biome. Both *Zygophyllum* species occurring in this Biome are widespread and adaptable species also occurring in several other Biomes, with the distribution of *Z. simplex* extending to northeast Africa, the Middle East and as far as India.

Nama Karoo Biome

The Nama Karoo occurs on the central plateau of the western half of southern Africa and extends in a narrow strip between the Desert and Savanna Biomes into Angola Figure 4.1). Altitudes range between 500—2000 m. Its distribution is determined primarily by the **low, unpredictable rainfall which occurs during summer as well as autumn months** and varies from 100—520 mm per year (Table 4.3). Substrates are derived from a varied geology and are a lime-rich, weakly developed soil over rock. The **dominant vegetation is a grassy, dwarf shrubland**. Most of the grasses are of the C4-type and together with the shrubs are deciduous in response to rainfall events. It is well known that many of the *Zygophyllum* species occurring in this vegetation are drought deciduous. **Severe frost is common and may occur for 5–6 months during winter** (Cowling & Hilton-Taylor 1997).

The genus *Zygophyllum* is second best represented in the Nama Karoo Biome by 20 out of 54 *Zygophyllum* species (Table 4.2). Although the low rainfall and high temperatures of this Biome fit the general growing preferences of *Zygophyllum,* it is probably the occurrence of severe frost over many months that limits speciation and additional infiltration of more species of *Zygophyllum* into this biome. The tendency to succulency in *Zygophyllum* is probably also a limiting factor as confirmed by the correlation found between the absence of frost and the presence of succulents (Werger 1986). Four *Zygophyllum* species are restricted to the Nama Karoo Biome and are indicated in bold print in Table 4.2. The Nama Karoo Biome shares ten *Zygophyllum* species with the Succulent Karoo Biome and five *Zygophyllum* species with the Desert Biome.

Succulent Karoo Biome

As the majority of *Zygophyllum* species occur in this Biome, a more detailed discussion of its attributes is given. This Biome occurs on flat or gently undulating plains interspersed with some hills and is situated on the western and southern side of the escarpment as well as north of the Cape Fold Belt, ending approximately near Luderitz (Figure 4.1). Most of the terrain is below 800 m above sea level, but in the

east this may rise to 1500 m. The substrates are derived from a variety of geological units and are lime-rich, weakly developed soils over rock. The major drainage systems are the Olifants, Doring and Orange Rivers to the west and the Gouritz River to the south-east of the Biome (Hoffman 1996). This Biome is primarily determined by the presence of **predictable, low winter rainfall and extreme summer aridity**. Its rainfall varies between 20—290 mm per year and summer temperatures in excess of 40°C are common. Desiccating, hot berg winds are experienced throughout the year (Hoffman 1996; Table 4.3). **Dwarf, succulent shrubs** belonging to the Mesembryanthemaceae, Crassulaceae and Zygophyllaceae, are **dominant** in the vegetation of the Succulent Karoo Biome. The **low, but predictable winter rains enhance shrubs** and bulbs, **especially those succulents which store water in their leaves**. According to Hilton-Taylor (1996) fog plays an important role in supplementing precipitation from rain and minimum temperatures are sufficiently high to prevent frosts. If frost occurs, it is never severe. Grasses are rare and of the C3-type. Axelrod & Raven (1978) considered the succulent Karoo one of the most extreme and unusual vegetation types in southern Africa, because the succulent shrubs (including *Zygophyllum*) and geophytes prominent in this vegetation type have produced such overwhelming outbursts of speciation that their extradesert affinities became obscured. The number of plant species, most of which are succulents, is very high and unparalleled in the world for an arid area of this size (Goldblatt 1978, Cowling & Hilton-Taylor 1997). High numbers of rare and endangered plant species occur in this Biome, including *Z. teretifolium*.

An explanation for the extraordinary high, rich diversity of species in this area is found in the climate of the region which is probably one of the most important driving forces for speciation in this region. The Succulent Karoo Biome is termed a "benign desert" when compared with other winter rainfall deserts of the world (Cowling & Pierce 1999). This is caused by three important features:

- rainfall is sparse and irregular but highly predictable.
- the influence of the cold Benguella current on its western boundary.
- the effect of the inland plateau lying to the east of the area.

Comparable deserts elsewhere experience highly unpredictable rains, resulting in prolonged droughts spread over years or could experience a season where most of the rain falls in one, great deluge, lasting hours. In contrast, the Succulent Karoo Biome receives **predictable** rains consisting of many and irregular, gentle showers spread out over the rainy season from May to mid-October. The cold Benguella current has an ameliorating effect on the large fluctuations in temperature experienced in this area, both daily and seasonally, thus enhancing growing conditions. At the same time the presence of the cold current diminishes the possibility of winter frosts or snowfalls. A correlation exists between the absence or rarity of night frosts with temperatures below -4°C and the presence of succulents in the winter rainfall area (Werger 1986). The cold current is also responsible for the phenomenon of regular blankets of fog and regular formation of dew over part of the area. Thus the growing season is extended and the meager annual precipitation of the area is considerably augmented. Cold winter temperatures are interrupted by hot berg winds creating ideal conditions for plant growth in the middle of the winter. These hot berg winds are caused by the presence of a high pressure cell over the inland plateau during winter months. Together, all these factors contribute to a relatively gentle environment for plants of the Succulent Karoo Biome compared to other winter rainfall deserts of the world (Cowling & Pierce 1999).

Zygophyllum is best represented in the Succulent Karoo Biome with 32 out of 54 *Zygophyllum* species occurring in it. Twelve *Zygophyllum* species are restricted to this Biome and are indicated in bold print in Table 4.2. The Succulent Karoo Biome shares four *Zygophyllum* species with the Thicket Biome, five with the Desert Biome, four with the Fynbos Biome and ten with the Nama Karoo Biome. With a few exceptions, almost all *Zygophyllum* species occurring in the Succulent Karoo Biome are leaf succulents (Kuun 1997), conforming to the description of Hoffman (1996).

The Succulent Karoo Biome includes several centres of endemism (Hilton-Taylor 1994, Van Wyk & Smith in press). One of them, the Gariep centre (Nordenstam 1966,1969, Cowling & Hilton-Taylor 1997), is situated in the lower Orange River basin, which is a mountainous region with a complex geology and very low rainfall. The very low precipitation (less than 50 mm per annum) is supplemented by coastal fog and supports a rich, xerophytic vegetation. This centre accomodates 363 endemics (Hilton-Taylor 1994), but according to Van Wyk & Smith (in press) this

figure can rise to 550. Twenty one of the 54 *Zygophyllum* species occur in the Gariep centre. Ten *Zygophyllum* species are restricted to this centre.

Although not treated as a centre of endemism by Van Wyk & Smith (in press), the Tanqua Karoo is another area of special interest in the Succulent Karoo Biome (Hilton-Taylor 1994). Situated on a plain lying between the Great Escarpment and the Cedarberg range of the Cape Fold Mountains, it falls in a rain shadow and experiences extreme aridity with rainfall seldom exceeding 50 mm per annum. The semi-desert nature of this area probably explains the relatively high number of nine *Zygophyllum* species occurring in this area, including one endemic, *Z. botulifolium*.

The map illustrating the diversity of *Zygophyllum* reveals several centres of diversity (Figures 4.2—4). Firstly, Figures 4.3 and 4.4 show that both subgenus *Agrophyllum* and subgenus *Zygophyllun* are concentrated in the Gariep centre, each with a substantial number of species although not all as endemics. The highest number of species per degree square in the Gariep centre is thirteen for subgenus *Agrophyllum* (Figure 4.4) and eight for subgenus *Zygophyllum* (Figure 4.3), giving a total of 21 for the genus (Figure 4.2). Another area of high diversity for *Zygophyllum* occurs in the Montagu area (3320 Montagu), which is included in the Little Karoo centre of endemism and in which ›240 endemic species occur (Van Wyk & Smith in press). Thirteen species of *Zygophyllum* occur in this centre of which eleven belong to subgenus *Zygophyllum* (Figure 4.3) and two to subgenus *Agrophyllum* (Figure 4.4). This is in contrast to the Gariep centre where the species of subgenus *Agrophyllum* constitute the majority. The presence of eleven species of subgenus *Zygophyllum* in this centre indicates that separate centres of speciation for the two subgenera occur. The main centre of speciation for subgenus *Agrophyllum* lies in the Gariep centre and that of the subgenus *Zygophyllum* in the Little Karoo, although the latter has two more, less important, centres of diversity, one in the Gariep centre and one in the Albany centre. These separate centres of speciation for the different subgenera of *Zygophyllum* correlates to the rather large distinction found in the macromorphology of species belonging to each subgenus. Collectively, the diversity map of *Zygophyllum* (Figure 4.2) reveals several centres of speciation. With the exception of the Albany centre, all of these centres of diversity are located within or close to

the borders of the Succulent Karoo Biome. The high numbers of *Zygophyllum* species found in these centres are probably reflecting on the inclusion of some elements from Biomes adjacent to the Succulent Karoo.

Fynbos Biome

The Fynbos Biome is considered by many to be synonymous with the Cape Floristic Region (Rebelo 1996). The geographical area covered by Fynbos (Figure 4.1) includes other vegetation types and is famous for its rich diversity of species (Goldblatt 1978). According to Rebelo (1996) the Fynbos Biome refers only to the two key vegetation types, **Fynbos** and **Renosterveld**, which are quite distinct having contrasting ecological systems. Renosterveld is mainly confined to fine-grained soil consisting of silts and clays derived from shale of the Malmesbury and Bokkeveld Groups as well as the Karoo Sequence. Rainfall is between 250—600 mm per annum and falls during winter (Table 4.3). The vegetation is characterized by plants with small, tough, grey leaves. Because of the high fertility of the soil much of the original area of Renosterveld has been converted to agriculture. In contrast to this, the many types of fynbos vegetation occur predominantly on well leached, infertile soils derived from the Cape Supergroup sandstone. The vegetation is rich with a high percentage of endemism. The majority of the endemics are confined to one or more of the Fynbos vegetation types. Fire is important in maintaining the composition of fynbos communities and many species occurring in Fynbos are specifically adapted to regular fires, resulting in regeneration from seeds only after a fire. Due to the infertile soils, little agricultural activities take place in the area of the Fynbos Biome.

The genus *Zygophyllum* is represented in the Fynbos Biome by 11 of the 54 *Zygophyllum* species, seven of which are confined to Fynbos and six to the Renosterveld subdivisions (Table 4.2). Only two *Zygophyllum* species are restricted to this Biome and are indicated in bold in Table 4.2. The Fynbos Biome shares four *Zygophyllum* species with the Succulent Karoo and three with the Thicket Biome respectively and none with the Nama Karoo Biome. Although the Fynbos Biome has many centres of endemism with many of its species having narrow distributional ranges, few *Zygophyllum* endemics occur in this region. The paucity of *Zygophyllum* species or *Zygophyllum* endemics in the otherwise endemic rich Fynbos Biome can

be attributed to the well known preference of the genus *Zygophyllum* for arid or semi-arid habitats where it reaches its highest degree of endemism.
A small enclaved centre of endemism, containing Renosterveld elements, occurs in the Kamiesberg area. It is a relatively small area surrounded by Succulent Karoo vegetation (Rourke 1990, Van Wyk & Smith in press) and accommodates 80–86 endemics (Cowling & Pierce 1999, Van Wyk & Smith in press). *Zygophyllum* is represented here by only one species, *Z. namaquanum,* which is not restricted to this centre. This species displays small, narrowly obovate leaflets that seldom become succulent. It is not drought deciduous either and thus more inclined to be a true fynbos element rather than a succulent one. It is found in the poorly known North-western Mountain Renosterveld (Rebelo 1996).

Desert Biome

The Desert Biome of Namibia is adjacent to the northern border of the Succulent Karoo Biome. It follows the Namibian coastline in a narrow strip from approximately Luderitz in the south towards Angola in the north (Figure 4.1). This biome comprises three vegetation zones in a east-west transect and with an accompanying decrease in rainfall (Irish 1994). The zone closest to the coast receives additional moisture from regular coastal fog. The Desert Biome has primarily summer rainfall which is extremely low, ranging from 11—22 mm per annum (Table 4.3).

The genus *Zygophyllum* is represented in the Desert Biome by ten out of 54 *Zygophyllum* species, which must be considered a high number when considering the paucity of species in the desert. Two *Zygophyllum* species are restricted to this biome and are indicated in bold inTable 4.2. The Desert Biome shares five of its *Zygophyllum* species with the Succulent Karoo and Nama Karoo Biome respectively.

Table 4.3. Climatological data for the various Biomes

Biome	Season of rainfall	Rainfall in mm/year	Presence of fog	Presence of frost	Tempera-ture in °C
Thicket	all seasons	250 - 1500	valley mist common	—	moderate, + extremes of 40°
Savanna	summer to autumn	200 - 500	rare	occasional	-10 - 45°
Grassland	summer	450 - 700	rare	severe frost in winter	-13 - 40°
Nama Karoo	summer, autumn	100 - 520	hardly ever	severe, for 5–6 months,	- 9 - 40°
Succulent Karoo	winter	20 - 290	common near coast	infrequent	40 ° +
Fynbos	autumn to spring	200 - 2000	common	rarely	6 - 40°
Desert	primarily summer	13 - 70	frequent to seldom	rarely	0 - 45°

Affinities of the Fynbos, Succulent Karoo and Nama Karoo Biomes

The Fynbos, Succulent Karoo and Nama Karoo Biome lie in close proximity to each other and together, occupy the southwestern part of the African continent (Figure 4.1). The Fynbos Biome represents the most southern Biome and stretches along the coastline in a wide strip from the Olifantsrivier mouth in the north to Grahamstown in the east. The Succulent Karoo Biome occurs as a wide strip along the west coast from the mouth of the Berg River in the south to around Luderitz in Namibia in the north, extending into the dry valleys of the Little Karoo. It is adjacent to both the Fynbos and Nama Karoo Biomes. The Nama Karoo Biome is land bound and occupies a large section of the interior of South Africa as well as Namibia, extending as a narrow belt into southern Angola. The rich diversity of biota found today in southern Africa and their relationships and adaptations to different environments are manifestations of events since the separation of Africa from Gondwana land between the mid-Jurassic and mid-Cretaceous times (Raven & Axelrod 1974). Africa also experienced major Tertiary palaeoceanographic events of the southern ocean which profoundly affected its climate with accompanying speciation and distribution of the flora (Deacon 1983). The development of the cold circum-antarctic Current, and at the same time the cold Benguella current along the west coast of southern Africa, affected the climate of the areas closest to the coast (currently including the Fynbos and Succulent Karoo Biomes). It caused increasing aridity which resulted in rapid evolution of drought-adapted plants (Goldblatt 1978). The climate gradually changed into a Mediterranean type of climate with cold, wet

winters followed by hot, dry summers. The influence of the Pleistocene glaciations further modified the climate and caused tremendous bursts of speciation in some genera in the Fynbos and adjacent arid areas, while elimination of others created new niches for those plants that could adapt (Goldblatt 1978). Because of the distance from the coast, the changes caused by the cold Benguella current had a less dramatic effect on the climate further inland (currently the Nama Karoo Biome area and others), which gradually developed into a summer rainfall region with dry and cold winters.

Similarities currently existing in the floristic composition of the Succulent Karoo and the Nama Karoo Biomes are probably relicts of the previous, much larger Nama Karoo which included the Succulent Karoo.

Although previously included in the Nama Karoo Biome, the Succulent Karoo Biome is at present considered to be a separate Biome with a contrasting climate to those of the Nama Karoo Biome (Low & Rebelo 1996). A debate developed, which is still ongoing, about the phytogeographic affinitiy of the Succulent Karoo. Acocks (1953) recognized a close relationship between the Cape and Karoo floras. Linder (1990) argued that these relationships are not straightforward when considering the close links between the floras of the Cape and Afromontane Regions of Africa. Many authors argue for the recognition of the Succulent Karoo Biome as part of a Greater Cape Flora (Bayer 1984, Gibbs Russel 1987, Hilton-Taylor 1987, Jürgens 1991, Jürgens 1997 and Van Wyk & Smith 1999, in press).

Results from the present study further substantiate the similarities in the floristic composition of the Succulent Karoo and Nama Karoo Biomes, because of the large number of *Zygophyllum* species shared by them. The Succulent Karoo Biome shares 10 out of its 32 *Zygophyllum* species, or about 30% with the Nama Karoo Biome and the Nama Karoo Biome shares 10 out of its 20 *Zygophyllum* species, or ca. 50% with the Succulent Karoo Biome. The figures comparing the Succulent Karoo with the Fynbos are less impressive, because the Succulent Karoo Biome shares only five of its 32 *Zygophyllum* species, or ca.15% with the Fynbos Biome. Although only relevant for one genus, these figures confirm a stronger affinity between Succulent Karoo and Nama Karoo vegetations than between Succulent Karoo and Fynbos vegetations. However, Stebbins (1952) hypothesized that dry and changing environments promote rapid evolution resulting in species diversity.

Speciation in Namaqualand (Succulent Karoo Biome) is a relatively recent phenomenon, since fossil records of succulent Mesembryanthemaceae from this region date back to only ca. 12,000 years ago (Cowling & Pierce 1999). The newly evolved species clusters are considered neo-endemics rather than relict members of older floras. The speciation and endemism of *Zygophyllum* in the Succulent Karoo Biome is probably also of recent origin and evolved during the Late Pliocene or Pleistocene age (Cowling & Hilton-Taylor, 1997) after the stabilization of the present climate and the resultant different Biomes.

African Arid disjunction

A survey through Index Kewensis reveals that the genus *Zygophyllum* comprises about 70 species in northeast Africa and Asia and that about 54 species (including the additions from this study) occur in southwest Africa, leaving a considerable disjunction between these two areas on the African continent (Figure 4.5). Only two taxa share the distribution of southwest and northeast Africa, Z. *simplex* and Z. *decumbens* var. *decumbens*. Several categories of north-south arid disjunctions are recognized by De Winter (1971). At a generic level, De Winter (1971) placed the genus *Fagonia* L. (*Zygophyllaceae*) in a category of genera represented in both northern and southern arid areas, but also more widespread. At a specific level, he placed *Z. simplex* in a category of species represented in both northern and southern arid areas and extending into other areas as well. Unfortunately De Winter (1971) did not include the widespread *Z. decumbens* var. *decumbens* in his tables and I have no distributional data for taxa of the northern hemisphere.

Levyns (1963) found no evidence of a southern, or Fynbos, origin for many species in the Succulent Karoo vegetation. When suggesting a northern hemisphere origin for some of these species, from where several migrations to the south occurred, she included *Zygophyllum*, which she considered an ancient genus because of its widespread distribution. According to De Winter (1971) it was Winterbottom in 1967 who first put forward the explanation of a former "arid corridor" connecting the northeast and southwest African areas and making migration of species possible at various and short intervals of time in the past. Balinsky (1962) showed that

northeast and southwest Africa are presently still connected by a relatively arid tract with low rainfall which could facilitate the migration of species to the present day.

African - Australian disjunction

Only two genera of the *Zygophyllaceae, Tribulus* and *Zygophyllum* are common to both Africa and Australia. Only one member of Zygophyllaceae, namely *Tribulus terrestris* L., was once collected in New Zealand but never became permanently established there (anon., 1988). The species of *Tribulus* are considered cosmopolitan weeds and their distributions fall outside the scope of this study. Although a large number of *Zygophyllum* species occur in both Australia and Africa, no species are shared by the two continents. In southern Africa the majority, or 33 of the 54 *Zygophyllum* species belong to subgenus *Zygophyllum,* most to § *Capensia.* A similar situation exist in Australia where the majority of its ca. 20 *Zygophyllum* species (Eichler 1986) also belong to subgenus *Zygophyllum.* Goldblatt (1978) attributed similar southern disjunctions in other genera mainly to long distance dispersal. Van Huyssteen (1937) considered a possible centre of origin for *Zygophyllum* in the arid parts of the northern hemisphere from where dispersal towards the southern hemisphere was possible along two different routes. One route of migration was along the "arid corridor" of Africa ending in southwestern Africa. *Z. simplex*, according to her of ancient origin, and widespread in both the northeast and southwest African regions, represent such a link (Van Huyssteen 1937). However, Sheahan (1991) considered *Z. simplex*, in its present form, as of recent evolutionary origin because of the developmental stages of the Kranz anatomy found in its leaflets. The second route of migration from an ancient, northern hemisphere centre of origin was from the arid Middle east, through India, "island hopping" across a possibly arid, dry-land Indonesian archipelago into Australia. The different routes of migration resulted in the presence of *Zygophyllum* species in both southwest Africa and Australia today, but represented by different species (Figure 4.5).

North - South American disunction

The genus Zygophyllum is absent from the New World except for a few introduced species (Fig. 4.5). The *Zygophyllaceae* present in the New World also exhibits a

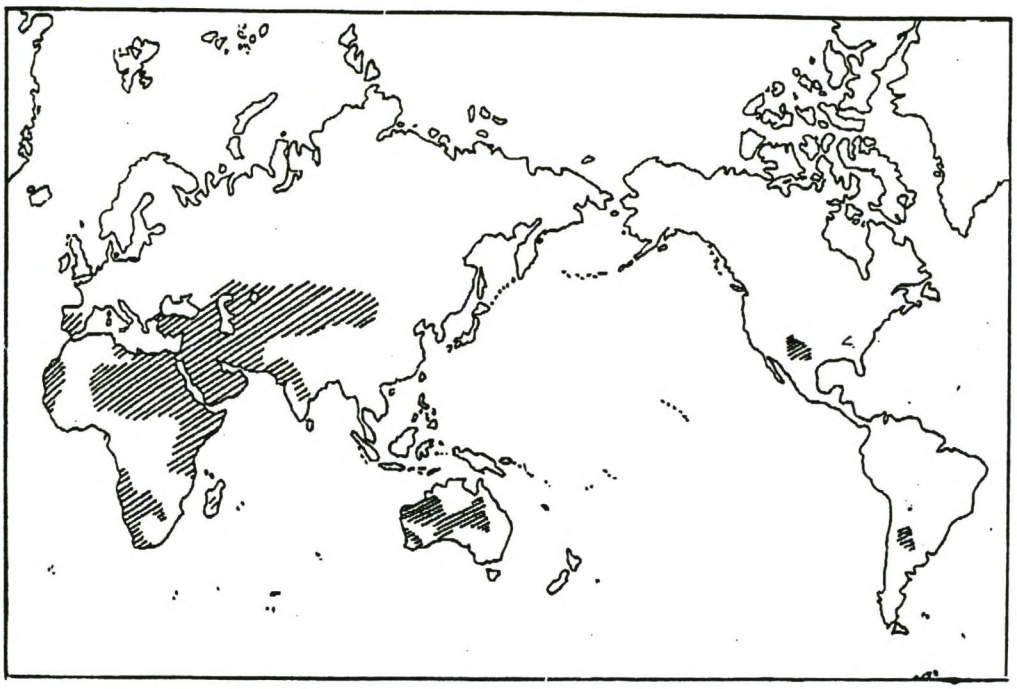


Figure 4.5. Geographical distribution of ***Zygophyllum*** with introductions to the New World added (Sheahan 1991).

disjunct pattern. There, several genera are represented in North- and in South-America, with large gaps in between (Porter 1974). An explanation for this disjunct pattern lies in long-distance dispersal for some genera and for others in both long-distance dispersal as well as sea-floor spreading (Porter 1974).

Appendix 1. *Zygophyllum* species listed under the various subdivisions of Biomes as in Low & Rebelo (1996).

BIOME	SUBDIVISION	SPECIES
Desert	Desert Biome - Namibia	Z. clavatum Z. cordifolium Z. cylindrifolium Z. inflatum Z. longicapsulare Z. orbiculatum Z. prismatocarpum Z. simplex Z. spongiosum Z. stapffii
Thicket	4 Dune Thicket	Z. calcicola Z. cordifolium Z. flexuosum Z. fulvum Z. maritimum
	5 Valley Thicket	Z. foetidum Z. maritimum
	6 Xeric Succulent Thicket	Z. debile Z. divaricatum Z. foetidum Z. lichtensteinianum Z. maritimum
	7 Mesic Succulent Thicket	Z. debile Z. divaricatum Z. foetidum Z. maritimum
	8 Spekboom Succulent Thicket	Z. debile Z. lichtensteinianum
Savanna	Savanna Biome - Namibia	Z. pubescens Z. simplex Z. spongiosum Z. tenue
	28 Shrubby Kalahari Dune Bushveld	Z. leucocladum
	30 Kalahari Plains Thornveld	Z. lichtensteinianum Z. microcarpum Z. pubescens
	31 Kalahari Mountain Bushveld	Z. pubescens
	32 Kimberley Thorn Bushveld	Z. incrustatum Z. leucocladum Z. microcarpum Z. pubescens Z. simplex
Grassland	39 Moist Cool Highveld Grassland	Z. simplex
	44 SE Mountain Grassland	Z. incrustatum
Nama Karoo	Nama Karoo Biome - Namibia	Z. chrysopteron Z. cretaceum Z. cylindrifolium

		Z. decumbens Z. giessii Z. incrustatum Z. inflatum Z. leucocladum Z. longicapsulare Z. longistipulatum Z. macrocarpon Z. microcarpum Z. pubescens Z. retrofractum Z. rigidum Z. simplex Z. spongiosum Z. tenue
	49 Bushmanland Nama Karoo	Z. chrysopteron Z. incrustatum Z. lichtensteinianum Z. microcarpum Z. retrofractum Z. simplex Z. tenue
	50 Upper Nama Karoo	Z. chrysopteron Z. incrustatum Z. lichtensteinianum Z. microcarpum
	51 Orange River Nama Karoo	Z. chrysopteron Z. cretaceum Z. decumbens Z. incrustatum Z. lichtensteinianum Z. microcarpum Z. retrofractum Z. simplex
	52 Eastern Mixed Nama Karoo	Z. incrustatum Z. lichtensteinianum Z. microcarpum Z. simplex
	53 Great Nama Karoo	Z. chrysopteron Z. incrustatum Z. lichtensteinianum Z. microcarpum Z. retrofractum Z. turbinatum
	54 Central Lower Nama Karoo	Z. chrysopteron Z. incrustatum Z. lichtensteinianum Z. microcarpum
Succulent Karoo	Succulent Karoo Biome - Nam.	Z. applanatum Z. clavatum Z. cretaceum Z. hirticaule Z. leptopetalum Z. longicapsulare Z. macrocarpon Z. patenticaule Z. prismatocarpum Z. pterocaule Z. pubescens Z. retrofractum Z. schreiberanum Z. segmentatum Z. simplex
	55 Strandveld Succulent Karoo	Z. cordifolium Z. cuneifolium
	56 Upland Succulent Karoo	Z. cordifolium Z. cretaceum

		Z. foetidum Z. fusiforme Z. leptopetalum Z. lichtensteinianum Z. macrocarpon Z. maculatum Z. microcarpum Z. namaquanum Z. prismatocarpum Z. pygmaeum Z. retrofractum Z. segmentatum Z. simplex
	57 Lowland Succulent Karoo	Z. botulifolium Z. chrysopteron Z. cordifolium Z. cuneifolium Z. foetidum Z. fusiforme Z. leptopetalum Z. maculatum Z. microcarpum Z. patenticaule Z. prismatocarpum Z. pterocaule Z. retrofractum Z. schreiberanum Z. simplex Z. teretifolium Z. turbinatum
	58 Little Succulent Karoo	Z. chrysopteron Z. debile Z. foetidum Z. lichtensteinianum Z. microcarpum Z. porphyrocaule Z. pygmaeum Z. turbinatum
Fynbos	59 NW Mountain Renosterveld	Z. namaquanum
	60 Escarpment Mountain Renosterveld	Z. pygmaeum
	61 Central Mountain Renosterveld	Z. debile Z. fulvum Z. porphyrocaule Z. pygmaeum Z. sessilifolium Z. spitskopense Z. swartbergense
	62 West Coast Renosterveld	Z. fulvum Z. sessilifolium Z. spitskopense
	63 S & SW Coast Renosterveld	Z. debile Z. fulvum Z. pygmaeum
	64 Mountain Fynbos	Z. debile Z. fulvum Z. sessilifolium Z. spitskopense Z. swartbergense
	65 Grassy Fynbos	Z. fulvum
	66 Laterite Fynbos	Z. calcicola
	67 Limestone Fynbos	Z. calcicola Z. fulvum Z. fuscatum
	68 Sand Plain Fynbos	Z. fulvum

CHAPTER 5

ECOLOGICAL ADAPTATIONS

Zygophyllum is a widespread genus, represented in many deserts and semi-deserts of the world, including some of the most arid habitats in which plant life is possible. Plants growing in these extreme environments are specially adapted for survival and the drier the habitat, the greater the functional modifications or adaptations towards xeromorphy which allow plants to survive (Sheahan 1991). Many species of *Zygophyllum* are xerophytic leaf succulents which is evident from their large numbers present in the Gariep Centre of endemism (Van Wyk & Smith, in press). This centre represents extreme xerophytic species that constitute a significant phytogeographical group (Nordenstam 1966). Xerophytes are defined as plants which can store water in their tissues as a mechanism to survive periods of drought and commonly have a fleshy appearance (Kurzweil & Smith 1995) but do not necessarily possess xeromorphic characters such as thick leathery leaves, thick cuticles and sunken stomata (Seddon 1974). Whereas many *Zygophyllum* species occur in the extreme conditions of the Gariep centre (Succulent Karoo Biome), some species are found in less harsh climates.

The anatomy of *Zygophyllum* species displays a variation in the thickness of the cuticle and epidermis, the amount of sclerenchyma present, the frequency of stomata present in the leaves, amphistomaty and a mesophyll differentiated into spongy parenchyma with water storing capacity (Sheahan 1991, Kuun 1997). Stocker (1960) found that the plasticity of some features is characteristic of desert plants. A mesophyll with water storing capacity is present in the few species with linear leaves, e.g. *Z. spinosum*, *Z. pygmaeum* and *Z. rogersii* (Kuun 1997), and in other, less xerophytic species occurring in the Fynbos and Thicket Biomes. Table 4.1 lists the species of *Zygophyllum* occurring in the different Biomes.

Vegetative adaptations

Reduction in leaf size and leaf shedding

The majority of southern African *Zygophyllum* species, like other xerophytes, have small leaves (Table 3.1) with an increase in volume relative to the area of external leaf surface. Such leaves are advantageous to xerophytes by reducing transpiring surfaces (Fahn 1964). Specht (1969) found a correlation between leaf size and nutrient stress but this is more severe in higher rainfall areas and is probably an explanation for the even smaller leaves found in the Fynbos vegetation when compared to those of the Succulent Karoo (Orchan 1986). However, large-leafed *Zygophyllum* species do occur, e.g. *Z. macrocarpon* and *Z. cordifolium,* but they developed other survival strategies as well. The bifoliolate, obovate leaflets of *Z. macrocarpon* are large (35–50 (90) x 30–45 (80) mm in size), thin and soft in texture and borne in an open manner (not inclined or conduplicate). Anatomically the soft leaves of *Z. macrocarpon* exhibit a well developed hypodermis (Kuun 1997) which serves as additional protection against excessive sunlight (Esau 1977). This species is restricted to the cooler, southern aspects of steep, narrow, east-west running valleys in the Richtersveld. By restricting its habitat, the soft, large leaves are protected from intense insolation. *Z. macrocarpon,* as well as several other *Zygophyllum* species, developed a **drought deciduous** response by shedding leaves partially or completely under water stress conditions. In *Z. morgsana* the leaflets are shed first and are followed by the petioles (Le Roux *et al.* 1989). This adaptation differs from seasonally deciduous plants which shed leaves in the off season (Von Willert *et al.* 1992). The simple and opposite leaves of *Z. cordifolium* are succulent and large (20–50 x 16–60 mm in size), and are borne in a **conduplicate** manner, each leaf shading the opposite leaf from solar radiation (Figure 7.22.1). This phenomenon is common in *Zygophyllum* and occurs in species with simple, sessile leaves or with petiolate, bifoliolate leaves, but is less obvious in species with sessile, bifoliolate leaves. Conduplication is an adaptation of leaves to light stress conditions.

The majority of *Zygophyllum* species use several strategies to survive harsh environmental conditions. This is shown by the species displaying a conduplicate orientation of their leaves as well as partial or complete leaf shedding in response to

drought. Partial leaf shedding refers to the shedding of all or only some leaflets leaving the green petioles for some time to photosynthesize.
Ismael (1983) reported an unique phenomenon of a change from simple to bifoliolate leaves in *Zygophyllum quatarense* Hadidi shortly after rain. Although not exactly the same, a similar phenomenon occurs in some small-leafed *Zygophyllum* species, e.g. *Z. retrofractum* and *Z. turbinatum* which shed their petiolate, bifoliolate leaves in a drought deciduous response, but when environmental conditions improve, quickly reproduce new leaves. These new leaves, which develop on short shoots and at different nodes along the stems and not exclusively at the branch apices only, represent all stages of development from simple or unifoliolate to a partly bifoliolate or complete bifoliolate stage (Figure 5.1). In *Z. retrofractum*, leaf shedding occurs throughout the year and the life duration of leaves is given as 6—12 months (Le Roux *et al.* 1989).

Leaf anatomy

Anatomical and physiological aspects of *Zygophyllaceae* were studied by Sheahan (1991) and the leaf anatomy of southern African *Zygophyllum* species by Kuun (1997) and were considered in this study and some remarks are relevant.

Amphistomaty is common in plants in hot, dry environments, allowing rapid growth under favourable conditions (Koller & Rost 1988). Almost all members of the *Zygophyllaceae* studied are amphistomatic, but display more stomata on the abaxial leaf surfaces than on the adaxial ones. The frequency and size of stomata are variable depending on environmental conditions (Sheahan 1991). The presence of abundant sclerenchyma in the leaf is regarded as a typical feature of desert plants (Fahn 1964), but most *Zygophyllum* leaves lack sclerenchyma tissue (Kuun 1997). This correlates to the deciduous nature of most *Zygophyllum* leaves which remain on plants for a relatively short period only and the absence of mechanical tissue means reduced metabolic cost to the plant (Sheahan 1991). In the absence of mechanical tissue, the necessary support could be supplied by turgor, and is probably a secondary function of the water storage tissues present in leaves of all *Zygophyllum* species (Sheahan 1991).

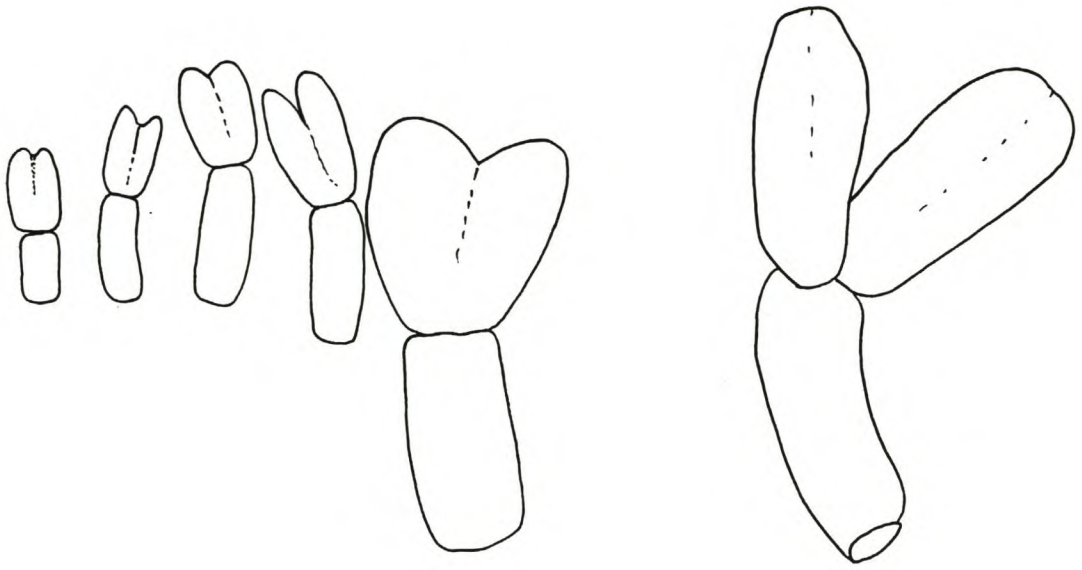


Figure 5.1. *Z. turbinatum, Van Zyl 4516*. Range of leaves at different stages of development.

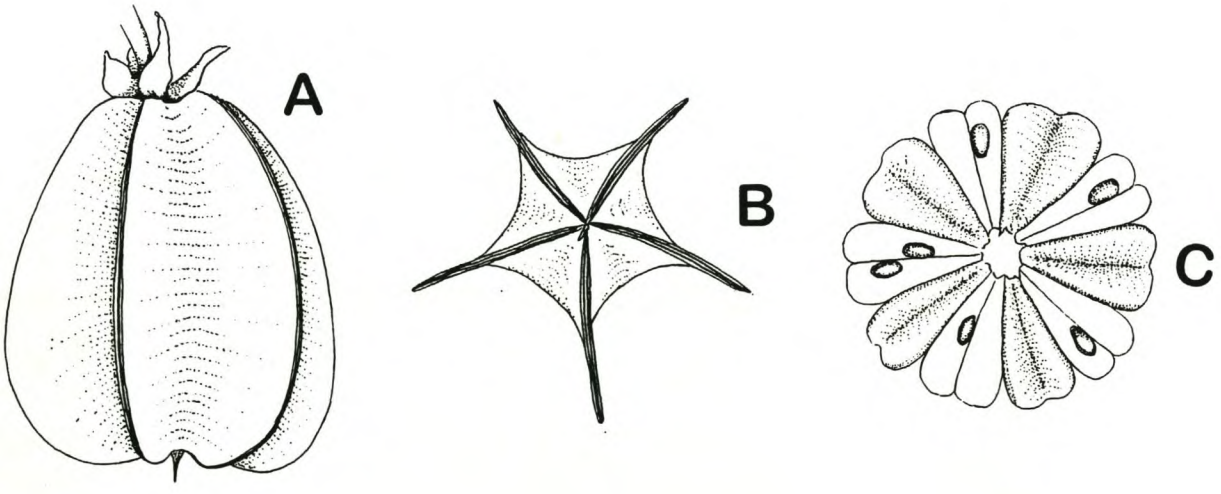


Figure 5.2. Fruit of *Z. stapffii*, *Van Zyl 3791*. A, mature, drooping 5-winged fruit in side-view; B, mature, drooping, 5-winged fruit in top-view; C, fruit in discoid stage during dry weather conditions with exocarpic and endocarpic sections alternating and seeds still attached to the endocarp.

Physiology

Among xerophytes the most common photosynthetic pathways are the CAM and the C3, whereas the C4 type is restricted to some halophytic succulents and a few annuals. In the Zygophyllaceae C4 photosynthesis is only found in annuals like *Z. simplex* and *Tribulus terrestris* (Zygophyllaceae) both of which occur in hot areas with summer rainfall or occur as summer annuals growing in winter rainfall areas (Von Willert *et al.* 1992). Although the CAM method of photosynthesis is considered more advantageous to xerophytes because stomata function during cooler, night temperatures, Sheahan (1991) found no evidence of the CAM mode of photosynthesis in the 37 species and 19 genera of *Zygophyllaceae* studied. The C3 mode of photosynthesis might be common, but is only recorded for a limited number of southern African members of *Zygophyllum,* e.g. *Z. prismatocarpum, Z. longicapsulare* and *Z. stapffii* as well as for *Augea capensis* Thunb. (Zygophyllaceae; Von Willert *et al.*1992) and for non southern African members of *Zygophyllum*, e.g. *Z. fabago* L., *Z. dumosum* Boiss. (Crookston & Moss 1972). Although the C3 method is considered disadvantageous to xerophytes because stomata function during hot, daylight hours, losing precious moisture (Cowling & Pierce 1999), many members of the Zygophyllaceae exhibiting the C3 pathway occur in the **cold** deserts of Asia (Sheahan 1991). In Zygophyllaceae the C4 syndrome could have arisen in arid areas which experience **high** summer temperatures and sufficient moisture for restricted periods only (Sheahan 1991). In the southern African region many of the Zygophyllaceae grow in hot deserts, but in spite of its apparent advantages, and being generally accepted as ecologically more advanced, the C4 phenomenon is rare in Zygophyllaceae and is recorded for only four members of the family, *Z. simplex, Tribulus terrestris* L., *T. zeyheri* Sond.and *Kallstroemia grandifolia* Torr. Ex A. Gray (Crookston & Moss 1972, Sheahan 1991) of which *Z. simplex* and *Tribulus terrestris* are two of the most widespread members of the family.

Brachyblasts

Under extreme climatic conditions special adaptations occur resulting in the presence of brachyblasts or short-shoots on stems. Short-shoots are present in the

vegetation of Mediterranean Type Ecosystems (Orchan 1989) and occur in the Zygophyllaceae (Sheahan & Chase 1996). They are present on the old stems of *Z. turbinatum* where they reach a length of one centimeter. Short shoots are scarred with the remains of leaf bases and stipules, are sometimes leafless or display a dense fascicle of leaves at their apices. Short shoots have a reduced internode length, whereas the nodal activity is preserved resulting in tight fascicles of leaves at its apex (Figure 7.14.1). *Z. turbinatum* occurs in the Tanqua and Moordenaars Karoo which experience a mediterranean type climate but of extreme conditions with the lowest rainfall in South Africa as well as high temperatures during summer months. The advantage of this ecological adaptation probably lies in a reduced metabolic cost, or a saving in precious moisture to the plant.

Reduction in plant size

An evolutionary trend towards smaller plant forms in more extreme habitats is a widespread phenomenon (Cowling & Pierce 1999). This is true for *Z. teretifolium,* which exhibits a remarkable reduction in size in the extreme conditions of the quartz pebble fields of the Knersvlakte. Here it attains a size of only 0.05 m in height and 0.2 m in diameter, compared to populations elsewhere in less harsh conditions, where it attains a height of 0.3 m and a diameter of 0.7 m. Many succulents with a neotenic life form, co-occur on these quartz pebble patches. Although *Z. teretifolium* is far from reaching the extremes of the neotenic state, it might be considered a new arrival to these special areas and could be in the process of adapting and evolving under the new conditions.

Increase in plant size and protection from sand-blasting by hummock formation

Some *Zygophyllum* species display a hummock formation in sandy, mildly windy areas, e.g. estuaries and along beaches whereas hummock formation is absent in sandy areas with high wind velocities. Wind blown sand accumulates against leafy plants which offer resistance to the wind current, dropping the sandy load. The accumulation of sand against resisting plants is a slow process and some species manage to grow through the sand, becoming taller and larger in size. The sandy accumulations also protect against wind abrasion by covering the stems and cause

a wind-sheltered area behind the plant in which more plant activity or growth is seen. Hummock formation occurs in *Z. clavatum* (Williamson 1996, 1997), *Z. patenticaule* and *Z. stapffii*. When forming hummocks, both *Z. clavatum* and *Z. stapffii* grow taller and larger, reaching sizes of 1 X 3 m (*Z. clávatum* usually is 0.5 x 1.0 m and *Z. stapffii* 0.6 x 1.0 m in size) whereas *Z. patenticaule* seemed to reach lesser heights but larger diameters. The value of hummock formation probably lies in a larger vegetative plant ensuring a larger production of fruits and seeds.

Change in habit - from erect to prostrate

In the Sperrgebiet of Namibia some erect species develop prostrate habits in response to wind action (Williamson 1997). This is especially true for species growing in sandy, windy corridors. When wind velocities are low, these species tend to form hummocks retaining their normal, erect habit by growing through the sandy cover, e.g. *Z. clavatum.* In sandy areas with higher wind velocity, the same species develop a prostrate habit in response to the force of the wind. Sand passes straight over the plants of *Z. clavatum*. This plasticity in habit allows *Z. clavatum* to survive in the adverse conditions experienced in windy deserts.

Change in period of growth activity

During late autumn, after the first winter rains, flowering and fruiting occur on shoots of the previous spring in *Z. cuneifolium*, a species occurring along the west coast. At the same time many germinating seeds and seedlings are seen usually in close proximity to mother plants. Mid winter cold brings a pause in growth activities, but vegetative growth proceeds again during spring and early summer with vigorous, new growth visible on all plants but without any flowers.

Resprouting ability from lower nodes on old stems

The seed production of *Z. spitskopense* is low due to excessive grazing pressure and the formation of 1-seeded loculi. However, its ability to resprout repeatedly from old wood (Figure 7.33.2.D) probably enables this species to overcome grazing pressures which is a very real hazard.

Pigmentation

Many *Zygophyllum* species develop a red pigmentation under extreme conditions of insolation experienced during summer months. All exposed vegetative parts of *Z. teretifolium*, growing in the extreme conditions of the quartz pebble patches of the Knersvlakte, develop a reddish colour during the summer months. *Z. cuneifolium* and *Z. lichtensteinianum*, occurring in less harsh conditions elsewhere, display a bronzed colour during the dry season. Of special interest is the red pigmentation which is restricted to the sunny side of the fruits of *Z. maritimum* and *Z. fulvum,* or which cover the total fruit of *Z. debile* and *Z. hirticaule*. This red colouring, induced by light stress, is believed to lower the absorptivity for visible solar radiation, thus protecting plants and their vulnerable seeds inside fruits against too much heat energy (Von Willert *et al.* 1992, Cowling & Pierce 1999). During less extreme conditions the plants return to their usually green colour.

Many *Zygophyllum* species display prominently white or whitish-coloured stems. This is not a pigmentation, but a stable property of the bark surface to reflect a large portion of the visible solar radiation (Von Willert *et al.* 1992). *Z. incrustatum* is an example of a species with white coloured stems which also displays prominent, dense pustulles on its white stems which further scatters incoming radiant light. Most of the white-stemmed *Zygophyllum* species occur in the harsh, semi-desert conditions found in southern Namibia and the Northern Cape. All *Zygophyllum* species occurring in milder climates, e.g. Fynbos, lack the red pigmentation or white coloured stems.

Trichomes

The glandular trichomes on the leaves of most *Fagonia* species (*Zygophyllaceae*) from hot deserts, together with their sticky secretions and soil particles adhering to them, increase the thickness of the diffusion boundary layer and reduce the radiation absorptance (Fahn & Sahimony 1996). Trichomes are present on young stems, peduncles, stem nodes and apices or leaf margins of many members of *Zygophyllaceae* and the density of indumentum is variable within a species and frequently of a caducous nature (Sheahan 1991). The present study revealed that

the majority of southern African *Zygophyllum* species display a protective indumentum only on axillary buds whereas mature vegetative plant parts lack an indumentum. This is in agreement with the findings of Von Willert *et al.* (1992) stating that hairy leaves are scarce among succulents when compared to other groups of plants, e.g. the herbs of humid climates. However, a few *Zygophyllum* species from the arid, southern Namibia, do possess trichomes. These trichomes are always unicellular and are either one-armed, slightly curly or straight and erect, as in *Z. hirticaule* and *Z. teretifolium* or two-armed and appressed, as in *Z. longicapsulare* and *Z. giessii* or glandular, as in *Z. decumbens* var. *decumbens*.

The exact function of trichomes is uncertain. Trichomes may increase reflectivity and consequently decrease absorptivity of solar radiation (Von Willert *et al.* 1992) or may serve as protection for young buds. Lyshede (1977) demonstrated that live trichomes are able to absorb water. Sheahan (1991) suggests that the caducous nature of trichomes found in *Zygophyllaceae* is indicative of a more important function in the water economy of the plant rather than in heat reduction. However, *Zygophyllaceae* occurring in the coastal Namib desert, where frequent fogs and dews occur, are either completely glabrous, e.g. *Augea capensis* and *Z. stapffii* or almost completely so, e.g. *Sisyndite spartea*.

FRUIT & SEED ADAPTATIONS

Psammophory

Psammophory is a condition where plant inhabitants of sandy deserts which experience frequent winds at high velocity, are covered with a sandy crust (Jürgens 1996). Psammophory protects plants against heat, desiccation, herbivory or insectivory, or against abrasion in areas with seasonally strong winds. This ecological adaptation is not evenly distributed in all deserts of the world (Jürgens 1996) but it occurs in the Namib, Northern Cape and Mediterranean regions (Jürgens 1996, Cowling & Pierce 1999). It occurs in *Fagonia* L.species (Zygophyllaceae) which become encrusted with soil particles adhering to the sticky secretions from their glands (Jürgens 1996). It is rare in *Zygophyllum,* occurring in two species only, e.g. *Z. longicapsulare* and *Z. pterocaule,* both with succulent fruits.

According to Ihlenfeldt (1989) succulents usually have dry fruits. Fleshy fruits, therefore, are rare in succulents, which make succulent, psammophoric fruits even rarer. *Z. longicapsulare* and *Z. pterocaule* occur in the extreme conditions of the Gariep centre and produce flowers and immature fruits in spring. During the summer the fruits become juicy and succulent. By mid summer, when temperatures are extremely high and the area is blasted by strong winds, the exocarp of the succulent fruits disintegrates due to sand blasting, resulting in the exposure of and possible damage to the partially enclosed seeds. Because of psammophory, its vulnerable seeds are protected. By now the succulent pericarp of the fruits has changed into a sticky mass covered by a crust of wind-blown sand, protecting the vulnerable, small seeds during the dry, hot season. In autumn, when temperatures are milder and the first rains usually occur, the sticky fruits disintegrate, releasing the seeds which can now germinate in milder environmental conditions (Figure 7.6.2). This phenomenon of diaspores released only when conditions are favourable, is termed **aestatiphorism** and is a widespread feature of desert plants (Von Willert *et al.* 1992).

Function of fruit wings

Many *Zygophyllum* species display **atelechory** (Van Rhede van Oudshoorn & Van Rooyen 1999) when diaspores lack structures facilitating long-distance dispersal (Ellner & Schmida 1981). However, wings are present on the fruits of some *Zygophyllum* species and occur in both subgenera (Tables 3.5; 3.6). The function of some of these wings is, however, debatable.

Subgenus *Zygophyllum*

Wings occur on the fruits of seven species in subgenus *Zygophyllum,* but they can hardly be for the purpose of wind dispersal since they are usually narrow and in relation to the size and width of the fruit very insignificant. Furthermore, the fruits in this subgenus are of a loculicidal type and, when mature, split into several pieces. The arillate seeds are disseminated at the same time and dropped to the ground close to the mother plant. The obvious presence of an aril (an elaiosome usually chemically attractive to ants) on the seeds in subgenus *Zygophyllum* is an indication of **myrmecochory** or ant dispersal of seeds. In subgenus *Zygophyllum* there seems

to be no need for wind dispersal of the fruit as it splits apart and the seeds are disseminated by ants. One could argue that the wings on the fruits serve no real purpose. However, there is one exception, *Z. morgsana*, with a large fruit (26–40 x 26–40 mm in size), and with wide (10–15 mm) wings. The fruit is classified as a septifragal fruit (Spjut 1994) with a different dehiscing mechanism. The exocarp stays intact, the endocarp separates along its ventral sutures, and the fruit opens incompletely and only on the inside. Rösch (1977) suggested that the true function of the fruit wings of *Z. morgsana* is to serve as "shaking" organs. The fruits are shaken by the wind and the seeds are released before the fruit disintegrates or is abscised.

Subgenus *Agrophyllum*

In subgenus *Agrophyllum* winged fruits occur in six species. Here the schizocarpic fruits dehisce in a septicidal manner (separating along ventral sutures) and split up in five separate mericarps. Each mericarp is compressed and has a membranous but firm texture, is very light and usually contains a few, small seeds (Table 3.7). This whole unit or mericarp can be considered a wing with the function of wind dispersal (**anemophyly**). After dispersal by the wind, the unit will eventually split open along its dorsal suture, which is sometimes visible as a small ridge, to disseminate the seeds. The dispersal method of the remainder of species in subgenus *Agrophyllum* is less clear. The separation of these fruits into five segments or mericarps is a fact and although these mericarps do not appear to be "wings", they could very well serve as wind blown structures, because the endocarp, acting as a "capsule" containing the small and light seeds, is strong and light.

Fruit dispersal as edible berries

Drupaceous, edible fruits in the subfamilies Nitrarioideae and Balanitoideae, Zygophyllaceae have been recorded by Engler (1931) and El Hadidi (1975). In southern Africa, *Zygophyllum* species with succulent fruits occur, which superficially resemble drupes or berries (Tables 3.5 and 3.6), but their consumption by birds or animals was never observed.

Myrmecochory

Myrmecochory is the dispersal of seeds by ants. The seeds typically have attached edible, pale-coloured food bodies or elaiosomes, which are chemically attractive to ants and consumed by them (Bond & Slingsby 1983). When harvester ants collect the seeds for consumption, it is not considered myrmecochory. Majer (1982) recorded a higher ant-plant interaction with elaiosomes present on seeds than when absent. Myrmecochoric seeds have dimensions that vary from 2 x 2 to 10 x 6 mm, and are typically hard with a smooth, shiny surfaces. *Zygophyllum* is included in myrmecochoric Fynbos genera studied by Bond & Slingsby (1983). They state that myrmecochory usually combines with a ballistic mechanism (a weight dropping to ground), which restricts long-distance dispersal to perhaps unsuitable spots and that myrmecochory is responsible for fast removal of seeds before damage by excessive insolation or consumption by rodents or birds. The distance of removal is short, usually no more than a few meters to a nest or midden where some seeds escape destruction and remain until germination. The quick removal of seeds with elaiosomes is enhanced by the rapid disintegration of the fruit into fragments (Van Rheede van Oudshoorn & Van Rooyen1999), which is extremely well illustrated by the species in the subgenus *Zygophyllum.*

Similar to Australia, the majority of myrmecochores in the Cape are restricted to a vegetation (in South Africa called Fynbos) which occur on nutrient-poor, acidic soils deficient in phosphorous and is fire-prone (Bond & Slingsby 1983). They further suggest that seedlings appear only after a fire when maternal competition is absent, thus posing no problem for seeds dispersed over short distances.

According to Bond & Slingsby (1983), only a few genera, including *Zygophyllum*, display both myrmecochorous and non-myrmecochorous species. The presence or absence of an elaiosome on seeds is one of the characters dividing the genus *Zygophyllum* into two subgenera. The seeds of the subgenus *Zygophyllum,* display elaiosomes whereas elaiosomes are absent in subgenus *Agrophyllum.* Only eleven out of the 33 *Zygophyllum* species in subgenus *Zygophyllum* occur in the Fynbos Biome. A question arises about the 22 species with elaiosomes of which most are found in the adjacent Karroid and renosterveld shrublands (Succulent Karoo Biome)

on nutrient-rich soils derived from shale. According to Rösch (1977), myrmecochory is rare in these areas.

If her statement is correct, then what is the function is of the elaiosome in the 22 elaiosome possessing *Zygophyllum* species occurring in the Succulent Karoo and Nama Karoo Biomes? Perhaps ants are present in the Succulent Karoo and Nama Karoo Biomes, but not yet as well studied as those in the Fynbos. Or perhaps the remaining 22 species are non-myrmecochorous. Bond & Slingsby (1983) suggested that genera displaying both myrmecochory and non-myrmecochory have a considerable evolutionary plasticity in terms of dispersal modes which are adapted to different ecological circumstance. Bond & Slingsby (1983) further suggested that myrmecochory as a mode of dispersal has evolved in response to ecological circumstances and is not a phyletic legacy. An explanation is also needed for the presence of the seven *Zygophyllum* species of the subgenus Zygophyllum in the Gariep centre displaying elaiosomes.

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Myxospermy

Myxospermy is the production of mucilage or slime by seeds when they are moistened. Gruber (1974) reported myxospermy in at least 49 angiosperm families. Hedge (1970), Swarbrick (1971) and Van Rheede Van Oudshoorn & Van Rooyen (1999) considered myxospermy a widespread phenomenon, but more common amongst xerophytic plants in arid regions. Hedge (1970) described two types of mucilage, a structureless type consisting of clear or opaque, jelly-like mucilage and a structured type consisting of mucilage which contain various inclusions such as spirals, threads or cell contents.

The exact function of myxospermy is debatable. The role of mucilage as an anchoring device is considered important (Hedge 1970). Van Rheede van Oudshoorn & Van Rooyen (1999) consider the main functions of myxospermy under dry conditions to be:

- safe anchorage close to the mother plants (or in other words preventing long-distance dispersal)
- protecting seeds from drying out

- protecting seeds from the abrasive powers of wind during unfavourable periods

In areas where micro-climatic as well as micro-edaphic conditions vary over short distances, such as deserts, long-distance removal of diaspores from the mother plant is considered detrimental (Van Rheede van Oudshoorn & Van Rooyen 1999). Gruber (1974) described the high forces necessary to remove seeds cemented to soil by mucilage as well as the extra mass and volume gained by myxospermous seeds by the adherence of sand grains. Myxospermy can either enhance (seeds cling to the fur or feet of animals and are transported) or suppress long-distance dispersal by sticking to nearby surfaces. Myxospermy also prevent seeds from moving too deep into the soil and away from required light conditions for germination (Van Rheede van Oudshoorn & Van Rooyen 1999). Myxospermy prevents seed collection by seed eaters in the desert (Gutterman 1996). While also affording anchorage against surface runoff and predation as soon as diaspores are buried, the main advantage of myxospermy lies in enhanced water uptake due to increased seed-soil contact (Van Rooyen *et al.* 1989).

As early as 1896, Engler already reported on the myxospermous seeds of the *Zygophyllaceae*. The seeds of all the southern African *Zygophyllum* species produce copious amounts of mucilage when immersed in water, but the production of mucilage depends on the maturity of the seed and is absent in immature seeds. The mucilage produced is of the structured type containing spiral inclusions, except in three species, *Z. simplex*, *Z. spongiosum* and *Z. inflatum* which produce a jelly-like, unstructured mucilage. The structure of the spiral inclusions differ in the two subgenera of *Zygophyllum*. In subgenus *Agrophyllum* the spirals are short and seems to "unravel" at their apices, to form a wine glass in side-view (Figure 3.14.B—C). In subgenus *Zygophyllum* the spirals are longer and of a uniform width (Figure 3.13.B—C). The nature of the mucilage appears to be stable and is of taxonomic importance at a subgeneric level.

Xerochasy

The term xerochasy refers to the opening and closing of the dispersal unit or organ of the mother plant as a function of moisture. The unit opens when dry and closes when wet (Van Rheede van Oudshoorn & Van Rooyen 1999). It is the direct opposite of hygrochasy, which refers to fruits that open when wet and close when dry. According to Zohary & Fahn (1941) xerochasy is a widespread phenomenon, in contrast to hygrochasy, which is confined to plants in the arid regions of the world. The detached fruit of *Zygophyllum stapffii* opens under dry conditions and closes again when moist conditions are experienced. This is an example of xerochasy. The fruit is described as a drooping, oblong or obovoid, 5-winged capsule, 17–21 x 14–16 mm in size, with a slender central body and membranous, 5—6 mm wide wings (Figure 5.2). When mature and under dry conditions, the endocarp and exocarp of the fruit separate along their dorsal sutures, leaving the five endocarpic sections to alternate with the five exocarpic sections while the fruit remains intact at its basal end. This separation of the fruit sections cause a change in the shape of the oblong fruit, which now become a discoid structure with the exocarpic sections flattened, with an open orientation, whereas the endocarpic sections remain half-closed retaining the seeds (Figure 5.2). This discoid structure is very light and is dispersed in a anemochoric manner. The xerochastic nature of the fruit is displayed during dry conditions when the fruit, in an open, discoid form, is dispersed by wind. When wet or moist conditions set in again, the fruit, still containing the seeds, closes and comes to rest in a favourable, moist spot for germination. The seeds of *Z. stapffii* display a short, thick, stronger funicle in contrast to the long, thin, weak funicle found in all other species of the subgenus *Agrophyllum*. The unusual and stronger funicles of *Z. stapffii* problaby keeps the seeds attached to the fruit while it tumbles in the wind and is probably another adaptation of this species to facilitate its special way of dispersal.

Chemical defence expressed as smell and taste

Crystals of various kinds, and of which some tested positive for calcium oxalate, are found abundantly in the tissues of the *Zygophyllaceae* (Sheahan 1991). Sheahan (1991) considered crystal type to be of diagnostic value and the frequency of occurrence of more ecological than taxonomic interest. Abundant crystals are recognized to be a feature of desert plants and especially common in plants growing

in saline soils (Metcalfe 1983). Crystals, toxic substances, tannins and volatile oils present in tissues form part of the chemical defense system against herbivores (Cowling & Pierce 1999). In *Zygophyllum*, druse and dentrite crystals (probably comprised of calcium oxalate, Cronquist 1981) occur in the leaves of the majority of species in subgenus *Agrophyllum*, but are almost absent in subgenus *Zygophyllum* (Kuun 1997). This correlates to the information about grazing damage or utilization by herbivores for the different species. A far greater number of grazed species occur in subgenus *Zygophyllum*, where crystals in leaf tissues are absent, or leaves are without chemical defense, than in the subgenus *Agrophyllum* where crystals are almost always present. The foul smell usually encountered in the vicinity of *Z. foetidum,* also correlates to the unpalatable nature of this species.

Optical properties of the testa of seeds in subgenus *Agrophyllum*

Optical properties are displayed by seeds of the subgenus *Agrophyllum.* When immersed in water, the testa becomes transparent and shiny and the embryo becomes clearly visible within. No literature references to this phenomenon was found, but a probable explanation could lie in the myxospermic nature of the seed which produce copious amounts of mucilage. The sticky mucilage collects grains of sand or other small debris, which cover the seed and add to its mass. The extra weight results in the seeds sinking deeper into the soil. At this stage the optical properties displayed by the testa could enhance the effect of light penetration through the soil layers, so enabling the embryo to germinate.

CHAPTER 6

DISCUSSION

Zygophyllum, as represented in the southern African region, is a large genus of 54 species, the majority of which are found in arid or semi-arid areas. Some species do occur in habitats with milder conditions. *Zygophyllum* species are characterized as shrubs or shrublets, rarely as herbaceous annuals or biennials, with simple, sessile leaves or simple, bifoliolate or petiolate, bifoliolate leaves of a succulent nature.

The division of *Zygophyllum* into two subgenera

Based on differences in floral and fruit morphology, the genus *Zygophyllum* is divided into subgenus *Zygophyllum* and subgenus *Agrophyllum* (Endlicher 1841, Van Huyssteen 1937). The staminal scales of subgenus *Zygophyllum* are described as large and the fruits as capsules splitting in a loculicidal manner. The staminal scales of subgenus *Agrophyllum* are described either as simple or biparted to near the base and the fruits as septicidal schizocarps splitting into five indihiscent mericarps. The present study confirmed this subdivision and it was corroborated by substantial, additional evidence as shown in the following discussion. In fact, a discussion of the genus, without taking the two subgenera into full consideration, is clumsy and of less value.

A clear distinction exists between the two subgenera *Zygophyllum* and *Agrophyllum* with regard to the morphology of their **young stems**. In subgenus *Zygophyllum* the young stems usually display a flat area on the ventral side and two prominent lateral ridges or the lateral ridges are less prominent and/or replaced with several less prominent ridges or to the other extreme the young stems of some species are round in cross section and completely striate or in one species rhombic in cross section and without ridges (Fig. 3.1). No correlation was found between the presence or absence of ridges or flat ventral areas and the number of stipules at the nodes. In subgenus *Agrophyllum* the young stems are round in cross section, usually with a prominent or poorly developed ventral groove or sometimes winged with a single wing or two wings in a vertical plane (Fig. 3.1). However, there are

exceptions to this, e.g. *Z. retrofractum* and its close allies, *Z. chrysopteron* and *Z. turbinatum* which display distinctly round young stems without grooves, wings or ridges. The shape of young stems is distinctive in the two subgenera and the presence of wings on the stems is used in the delimitation of § *Prismatica*.

In the majority of *Zygophyllum* species all plant parts are glabrous but when an **indumentum** is present it always consists of unicellular hairs which are of different types in the two subgenera. In subgenus *Zygophyllum* the hairs are simple, elongated or short, dense or sparse, curly or straight, whereas in subgenus *Agrophyllum* the hairs are two-armed, T-shaped and appressed. The usually dense, white, appressed trichomes results in a whitish appearance of plant parts. These two-armed, T-shaped hairs are restricted to § *Cinerea* and § *Alata* and are used to delimit these sections.

All the species of *Zygophyllum* are **stipulate**. Some stipules are free and usually present as two stipules on both the ventral and dorsal side of the stems, or the stipules are completely fused and present as interpetiolar stipules, one only between leaf bases at the nodes, or the stipules are partially fused, with bases fused and apices free. A distinction exists between the stipule states of the two subgenera. Most of the species of subgenus *Agrophyllum*, with the exception of *Z. stapffii*, display separate, free stipules, two each on the ventral side and two each on the dorsal side of the stems. This is in contrast to the presence of fused or partially fused stipules which is the norm in subgenus *Zygophyllum*. The presence of stipules is considered a primitive state in evolutionary trends (Radford *et al.* 1974). The fused stipules present in subgenus *Zygophyllum* is considered more advanced than the free stipules occurring in subgenus *Agrophyllum* (Foster & Gifford 1974) although in a later edition of the same work no mention is made of evolutionary trends concerning stipules (Gifford & Foster 1988).

Leaves of *Zygophyllum* are always opposite with the exception of *Z. simplex*. Only the older leaves of this species are opposite, whereas all younger leaves are situated opposite a branch representing a sympodial branching of the stem. Opposite leaves are considered as advanced by Radford *et al.* (1974). Leaf **types**

found in *Zygophyllum* vary and can be sessile and simple; sessile and bifoliolate; petiolate and bifoliolate; petiolate and trifoliolate (Table 3.1). The majority of species have either sessile, bifoliolate or petiolate, bifoliolate leaves, whereas species with simple, sessile leaves are few in number and only one species displays leaves of a petiolate, trifoliolate leaf type. The petiolate, bifoliolate leaves of *Zygophyllum* represent a reduction of the pinnate leaf type occurring in the Zygophyllaceae (Weberling 1956). At the same time it can be said that in *Zygophyllum,* sessile leaves also represent a reduction and are more advanced than petiolate leaves. The simple leaf type, present in a few species only, probably represents a further reduction or loss of leaflets and can be considered as the most advanced leaf state in *Zygophyllum*. The simple leaf state is present in subgenus *Agrophyllum* (six species) as well as in subgenus *Zygophyllum* (three species). The sessile, bifoliolate state is absent in subgenus *Agrophyllum*, whereas the more primitive, petiolate state occurs in both subgenera, but are represented by a larger number of species in the subgenus *Agrophyllum.* An explanation for the absence of the sessile and bifoliolate leaf type in subgenus *Agrophyllum* could probably lie in its distribution with its centre of diversity situated in the extreme conditions of the Gariep centre of endemism. *Zygophyllum* species occurring in this area are all specially adapted for survival in several, different ways. Conduplication of leaflets is one of these adaptations serving as a protection against excessive insolation. Sheahan (1991) suggested that the petiolate leaf state enhances the conduplication of leaflets more than the sessile leaf state. Thus, although the sessile leaf state in *Zygophyllum* is considered a more advanced state, the petiolate leaf state in the subgenus *Agrophyllum*, must be regarded as a secondary advanced state.

Van Huyssteen (1937) considered the subgenus *Agrophyllum* to be the ancestral group within *Zygophyllum.* She regarded *Z. simplex,* which belongs to the subgenus *Agrophyllum,* as of ancient origin, because it is both a polymorphic and a widespread species providing a link between the southwest African and northeast African species of *Zygophyllum. Z. simplex,* occurring in both the northeast African and southwest African areas, displays simple, sessile leaves which are probably derived from petiolate, bifoliolate ancestors. Many *Zygophyllum* species display a drought deciduous response to water stress and in *Z. simplex* this probably resulted

in the permanent loss of leaflets with the remaining petioles now photosynthesising. The C4 method of photosynthesis is present in *Z. simplex* from the northeast African area (anatomical evidence as well physiologically tested, Sheahan 1991) and probably also from the southwest African area (anatomical evidence without any physiological testing, Kuun 1997). This method of photosynthesis is considered to be of relatively recent origin (Peisker 1986, in Sheahan 1991) and it seems probable that *Z. simplex,* in its present form, in contrast to Van Huyssteen's belief, is of recent evolutionary origin (Sheahan 1991). Whichever view is accepted, the reduction to simple leaves as well as the development of the C4 syndrome currently found in *Z. simplex*, must have occurred before the disjunction of its distribution into the northeast African and southwest African areas.

Simple leaves do occur in subgenus *Zygophyllum*, § *Paradoxa*, a section that is confined to the southwest African area, with no representatives elsewhere. The reduction to the simple leaf state here, probably occurred at a much later date than in subgenus *Agrophyllum*.

The abundance of leaf crystals present in the leaves of the species in subgenus *Agrophyllum* and their almost absence in subgenus *Zygophyllum* (Kuun 1997) further corroborate the distinction between the two subgenera of *Zygophyllum.*

The majority of *Zygophyllum* species display **indeterminate inflorescences** (Cronquist 1981) or **polytelic synflorescences** (Weberling 1992). This type of inflorescence is without a terminal flower and represented in *Zygophyllum* species as single or clustered, axillary flowers. Cymous inflorescences, considered more primitive (Takhtajan 1980) are restricted to subgenus *Agrophyllum*, and occur in the three species of § *Prismatica* as well as in one species of § *Bipartita*, *Z. decumbens* var. *decumbens*. All four of these species exhibit a scorpioid cyme, contracted and dense in *Z. prismatocarpum* and *Z. decumbens* var. *decumbens,* elongated and with regularly spaced flowers in *Z. patenticaule* and short and reduced with few flowers in *Z. pterocaule.*

The **flowers** of *Zygophyllum* show distinctly different characters in the two subgenera. The majority of the species in subgenus *Agrophyllum* display small, perfectly actinomorphic flowers with unmarked petals, usually of a white colour,

rarely yellow or orange. The actinomorphic floral state is considered primitive (Radford *et al.* 1974). In subgenus *Zygophyllum* a tendency towards zygomorphism is detected when analyzing the basal markings of most and petal orientation of some species. The basal markings or nectar guides of many flowers are usually more prominent on the two posterior petals than on the anterior three. During anthesis a few species display a different petal orientation where the two posterior petals are reflexed and the three anterior petals extended. These two different characters present in subgenus *Zygophylllum* can be interpreted as a preliminary trend towards zygomorphism and occurs together with a praemorse state of the petals. Zygomorphism is considered an advanced state (Radford *et al.* 1974). The zygomorphic tendency in subgenus *Zygophyllum* superficially resembles the state of the flowers of *Pelargonium* L'Herit., probably one of the reasons why older classification systems (Bentham & Hooker 1862, Engler 1931) placed Zygophyllaceae and Geraniaceae in the same order Geraniales. Species with a different orientation of the petals are rare in *Zygophyllum,* and this different petal orientation usually occurs in combination with red veins on the petals which are also rare. Only three species of § *Capensia, Z. leptopetalum*, *Z. sessilifolium* and *Z. spitskopensis,* exhibit differently orientated together with red-veined petals.

There is no reduction in **sepal and petal** number and five of each are always present, with the exception of *Z. morgsana*, which is tetramerous, with only four sepals and petals. This is in contrast to the Australian *Zygophyllum* species where sepal and petal number varies between 3—5 per flower and where these numbers are of taxonomic value. Sepal shape shows another distinction between the two subgenera. Most species in subgenus *Agrophyllum* display free **sepals** that are quite succulent, often cucullate and always articulate, soon deciduous, thus contributing to the water economy of the plant. Although the sepals are free, which is usually considered a primitive trend, their succulency and the presence of an articulation zone, may be considered as advanced trends. The exception here is *Z. stapffii,* which has sepals that are slightly connate at base. In subgenus *Zygophyllum* sepals are not articulate nor succulent, having a membranous texture and remain attached to the developing fruit for a while before dropping off.

The species in subgenus *Agrophyllum* usually have **petals** that are spathulate and with long claws, whereas in subgenus *Zygophyllum* petals are subrotund or obovate or elliptic, but never with a long claw.

The **androecium** of *Zygophyllum* is actinomorphic and obdiplostemonous and consists of ten, free stamens, arranged in two whorls of five each (Figure 3.5). *Z. morgsana* is the only exception in this respect with eight stamens only (4-merous state). The stamens of each whorl are similar in length, whereas a slight difference in length is found between the two whorls. All species of *Zygophyllum* display a staminal scale situated near the base and on the ventral side of the filaments. Again, a distinction is found in the staminal scale morphology of the two subgenera (Figure 3.6). In subgenus *Agrophyllum* the staminal scales include Type 1—3 (Table 3.3), whereas subgenus *Zygophyllum* displays only Type 3—4. The overlap in staminal scale (type 3) occurs in the two species of § *Cinerea* of subgenus *Agrophyllum* which display staminal scales that are simple, elliptic or ovate, with lacerate margins and with a filament to scale ratio of 3 : 1. This is similar to the majority of the staminal scales found in subgenus *Zygophyllum*. When comparing the two subgenera of *Zygophyllum*, the type of staminal scales found in § *Cinerea* is quite remarkable because it forms a singular link of conformity between the two subgenera.

An intrastaminal, hypogynous **nectar disc** is present in all *Zygophyllum* species and the character of this disc is distinct for the two subgenera. In subgenus *Zygophyllum* no variation occurs in the morphology of the disc which is described as fleshy, covered with papillae and regularly 10-angled (Figure 3.7.1—2). The angles correspond to the indentations made by the attachments of the filaments with their staminal scales and become visible only after the removal of these structures. In contrast to subgenus *Zygophyllum* a large variation occurs in the morphology of nectar discs in subgenus *Agrophyllum* (Table 3.4). Here, the disc can be fleshy and smooth, never papillate, regularly 10-angled or 10-lobed, the lobes sometimes prominent and arranged in 5 pairs, or less so. The variation found here can be used in the delimitation of some of the sections, e.g. § *Annua* and § *Prismatica*. The large variation present in the morphology of nectar discs in subgenus *Agrophyllum* is

probably an indication of more time available for differentiation and therefor probably of a more ancient origin for this subgenus compared to subgenus *Zygophyllum* where no variation occurs. The prominently outward and upward orientated lobes found in subgenus *Agrophyllum* is probably an evolutionary development in the direction of separate nectaries similar to those of the genus *Tribulus* (Zygophyllaceae; Schweickerdt 1937, Brown 1938). The nectaries in *Tribulus* vary from nectar discs with lobes and indentations to separate nectaries. The nature of the ovary in *Zygophyllum*, whether it is spherical, lobed or parted, probably also influence the shape of the nectar disc.

The **gynoecium** in *Zygophyllum* is sessile, (4-) 5-locular, superior, variable in shape, from globose, ovoid, conical, lobed, parted to rudimentary winged (Figure 3.7). The ovary usually displays five, clearly visible, sutures indicative of its 5-locular state. The majority of ovaries are glabrous. Hairy or globulate ovaries are rare and occur in subgenus *Agrophyllum*, e.g. hairy ovaries in *Z. microcarpum* and *Z. longistipulatum* (Figure 7.18.1), or globulate ovaries in *Z. longicapsulare* and *Z. applanatum* (Figure 7.7.1). The placentation is axile and the ovules epitropous, variable in number from few to many per locule. Many ovules are abortive resulting in empty or 1-seeded locules. The style arises from the summit of the ovary, is terete and has a terminal, simple, not persistent stigma. Only *Z. simplex* displays a slightly capitate stigma.

The genus *Zygophyllum* has several, **distinctive methods of dehiscence,** which are used in the delimitation of the subgenera. The fruits in subgenus *Zygophyllum* are capsules dehiscing in a loculicidal manner, breaking up into separate valves and at the same time dispersing the seeds close to the mother plant. In subgenus *Agrophyllum* the fruits are schizocarps which dehisce in a septicidal manner into five mericarps. The separate mericarps, each containing seeds, are dispersed as a unit, and the dispersal could be over a long or short distance.

In each of these two major groups, a single exception occurs with regard to the method of dehiscence. The fruits of *Z. morgsana,* subgenus *Zygophyllum*, are large and wide-winged. Rösch (1977) suggested that the function of the wings of the fruit of *Z. morgsana* is to serve as "shaking" organs. The fruits are shaken by the wind and the seeds are released from the locules because the endocarp has separated

from the central axis (opened) before the fruit disintegrates (exocarp still intact) or is abscised. This type of fruit is classified as septifragal (Spjit 1994), because the fruit opens incompletely. Although the method of dehiscence differs, the seeds are also dispersed close to the mother plant, in a similar way to the other species of the subgenus.

The fruits of *Z. stapffii*, subgenus *Agrophyllum,* display a xerochastic method of dehiscence. Its detached, 5-winged fruits open in response to dry air, and close again in response to moisture (opposite of hygrochasy). When open, the fruit becomes a light, discoid structure still retaining the seeds and the fruit is dispersed as a unit, probably in an anemochoric manner, similar to other species in this subgenus (Figure 5.2). Thus, at least four distinct dehiscing methods occur in the fruits of *Zygophyllum.*

According to Cronquist (1981) the most primitive type of capsular dehiscence is septicidal and the carpels merely separate along the ventral suture. Cronquist (1981) considers loculicidal dehiscence the more efficient and probably the more advanced method of liberating the seeds. Although the mericarps, found in subgenus *Agrophyllum,* are derived from a septicidal dehiscing schizocarp which is considered primitive (Cronquist 1981), I regard septicidal dehiscence of these mericarps as a secondary dehiscing mechanism, because after their initial dispersal as a seed-containing unit, a less important (dormant) dorsal suture splits open, allowing the liberation of the seeds. This additional, or secondary, method of dehiscence must surely be rated as an advanced trend, perhaps more advanced than the loculicidal method of dehiscence.

The different **fruit types** and dehiscing methods found in *Zygophyllym* are the result of the variation found in its fruit morphology which is distinct for the two subgenera and diagnostic at subgeneric level. The fruits of subgenus *Zygophyllum* (loculicidal, disintegrating) are categorized as 5-lobed and without ridges, 5-lobed with ridges or it can be 5-lobed with wings (Figures 3.8—10). The fruits usually display a dorsal ridge where splitting occurs. The nature of the ridges on the lobes varies. Some are thin and fine, the majority are wider and stronger and in a few species the ridges are broad and flat (Figures 3.8—10). The wings are usually membranous, reticulate-

veined and at least 2 mm in width, culminating in the wide-winged *Z. morgsana* with wings up to 15 mm wide (Figure 3.10.I—J). These fruit characters occur in combination with spherical, subspherical, oblong, ovoid or prismatic shapes of the fruit (Table 3.5). Noteworthy is the near absence of fruit succulency in this subgenus.

The fruits of subgenus *Agrophyllum* (septicidal) divide into seed-containing mericarps, which are dispersed as separate units and only break up after dispersal, therefore they almost lack the ridges which are so prominent on the fruits of subgenus *Zygophyllum*. The fruits in subgenus *Agrophyllum* are categorized as 5-lobed, 5-parted or 5-winged (Figures 3.11—13), characters which occur in combination with spherical, oblong, obovoid, ovoid, ellipsoid, rhomboid, turbinoid, or prismatoid shapes of the fruits (Table 3.6). Succulency is common in the fruit of this subgenus and although some authors describe the succulent fruit of some species in Zygophyllaceae as berries or as drupaceous fruit (El Haddidi 1975), or as fleshy drupes in *Balanites* and *Nitraria* (Sheahan 1991), the succulent fruits of subgenus *Agrophyllum* when dry, always become but a collection of mericarps, originating from a schizocarp. The extended period needed for the maturation of succulent fruits is explained by Cronquist (1981) in his statement that the evolution of succulent fruits may proceed concurrently with suppression of dehiscence.

A clear distinction is found between the **morphology of the seeds** of the two subgenera of *Zygophyllum.* In subgenus *Zygophyllum* the seeds are oblong with a dark, smooth and glossy testa and arillate. Endosperm is present but in reduced quantities and the embryo is large and well differentiated. The smallest seeds are 3 x 1.5 mm and the largest 6–7 x 3 mm in size (Figure 3.14.A; Table 3.7). Most of these characters are considered as advanced evolutionary trends (Radford *et al.* 1974, Takhtajan 1980, Cronquist 1981). In subgenus *Agrophyllum* the seeds are compressed pyriform and without an aril, but when immature attached with a long funicle which is lost at a later stage. The testa is dark and grainy, the endosperm is absent and the embryo is large and well differentiated. The smallest seeds are 0.8–1.0 x 0.3–0.5 mm and the largest 3–4 x 2.0–2.5 mm in size (Figure 3.15.A; Table 3.7). Although the seed lacks an aril, which is considered a primitive character, most

of its other characters qualifies as advanced (Radford *et al.* 1974, Takhtajan 1980, Cronquist 1981). The testa of seeds of subgenus *Agrophyllum* displays optical properties when immersed in water and becomes transparent and shiny with the embryo clearly visible inside, which must surely be rated as an advanced trend (no literature references to this phenomenon found).

When the seed is immersed in water, another distinction between the subgenera becomes evident. Wet seeds of all *Zygophyllum* species produce a structured type of **mucilage** which contain spiral inclusions (Engler 1931, Hedge 1970, Gruber 1974). In subgenus *Zygophyllum* the spirals are always long and of uniform width, whereas in subgenus *Agrophyllum*, the spirals are shorter and they seem to unravel at their apices, resembling the shape of a wine glass in side-view (Figures 3.14.B–C; 3.15.B—C). The three species in § *Annua*, subgenus *Agrophyllum*, are exceptional because of they produce unstructured, jelly-like mucilage.

The **seed dispersal mechanism** in subgenus *Zygophyllum* with its loculicidal capsules is via myrmecochory (Bond & Slingsby 1983), and considered highly specialized (Takhtajan 1980). The finding of Bond & Slingsby (1983) is in no way disputed, but an explanation is still needed for the myxospermic condition of the seeds in this subgenus. The question must be asked what is the use of myxospermy if the seeds are dispersed via myrmecochory.
In subgenus *Agrophyllum* the schizocarpic fruit divides in seed-containing mericarps which are probably wind-dispersed as a unit. Here, the myxospermic nature of seeds serve well to protect and anchor the small seeds after their release from the mericarps.

The distributional data for *Zygophyllum* display several centres of diversity, most of which are located within or near the borders of the Succulent Karoo Biome (Figure 4.2). When separate distribution maps for the two subgenera are studied, another distinction between them becomes evident in the presence of separate centres of diversity for each. The subgenus *Agrophyllum* and subgenus *Zygophyllun* are both concentrated in the Gariep centre with thirteen and eight species respectively (Figures 4.3 and 4.4). In the Little Karoo centre of endemism (3320 Montagu)

thirteen species of *Zygophyllum* occur of which eleven species belong to subgenus *Zygophyllum* (Figure 4.3) and only two species to subgenus *Agrophyllum* (Figure 4.4). This is in contrast to the Gariep centre where the species of subgenus *Agrophyllum* constitute the majority. Thus, the main centre of speciation for subgenus *Agrophyllum* lies in the Gariep centre and that of the subgenus *Zygophyllum* in the Little Karoo, although the latter has two more, less important, centres of diversity, one in the Gariep centre and one in the Albany centre. These different centres of diversity for the subgenera is another reflection on their large and obvious differences.

CONCLUDING REMARKS

From the previous discussion it is clear that the subgenus *Agrophyllum* is advanced with regard to petiolate, bifoliolate leaves as well as to simple leaves present in some species, the presence of C4 metobolism, specially adapted succulent and articulate sepals contributing to the water efficiency of plants, variable morphology of its nectar disc, septicidal schizocarps displaying a secondary mechanism of dehiscence along a dorsal suture, small sized seeds, absence of endosperm, well differentiated and large embryo, myxospermic testa with optical properties and its centre of speciation in the extreme conditions of the Gariep centre.

Subgenus *Zygophyllum* is advanced with regard to its interpetiolar stipules, many species with opposite, bifoliolate leaves, some species with sessile leaves, zygomorphism displayed in some floral characters, reduction from five to four in floral parts displayed by *Z. morgsana,* capsules splitting in a loculicidal manner, small sized seeds, endosperm present but in small quantities, well differentiated and large embryo, arillate, myxospermic seeds and a myrmecochorous method of seed dispersal.

On morphological characters alone the evolutionary trends in the two subgenera are difficult to evaluate and it is also difficult to evaluate which one is the ancestral group and which the derived taxon.

Both subgenera are widespread, occurring in the southwest African and northeast African areas as well as in Asia and Australia. It seems, though, that the subgenus *Zygophyllum* underwent speciation on a larger scale, resulting in more species than in subgenus *Agrophyllum*.

Both Engler (1896) and Van Huyssteen (1937) considered subgenus *Agrophyllum* to be the ancestral group of the genus. Van Huyssteen (1937) regarded *Z. simplex,* subgenus *Agrophyllum,* as of ancient origin because it is both polymorphic and the most widespread species, providing a link on a sub-generic or species-level between the northeast African and the southwest African species of *Zygophyllum*. No such link is currently known to exist in subgenus *Zygophyllum* and it is probably safe to argue that subgenus *Zygophyllum* is of more recent origin than subgenus *Agrophyllum*.

The macromorphology of *Zygophyllum* clearly and overwhelmingly supports the division of *Zygophyllum* into subgenera *Zygophyllum* and *Agrophyllum*. Many striking differences regarding vegetative and reproductive morphology and only a few similarities between the subgenera were found. The question must be asked whether the subgenera should become different genera. An extended study, including material from the other geographical regions where *Zygophyllum* occurs, should be undertaken before a decision in this direction is taken. DNA analysis could also contribute to this decision .

The division of the subgenera *Zygophyllum* and *Agrophyllum* into several sections each is confirmed and corroborated by additional information. The monotypic § *Morgsana* is transferred from subgenus *Agrophyllum* to subgenus *Zygophyllum* to which it shows a greater affinity with regard to its floral and fruit morphology (Table 7.11). The monotypic § *Grandifolia* is transferred from subgenus *Zygophyllum* to subgenus *Agrophyllum* for similar reasons (Table 7.6). To be consequent, both sections *Morgsana* and *Grandifolia* should perhaps be regarded as new subgenera because of their distinctly different methods of fruit dehiscence but since this study is based on macromorphology alone, a move in this direction is perhaps too early and

should be postponed until more information based on DNA analysis becomes available.

The § *Prismatica* is newly described and comprizes three species, *Z. prismatocarpum* Sond., *Z. patenticaule* Van Zyl, stat. nov., and *Z. pterocaule* Van Zyl sp. nov. all with simple, sessile leaves. This treatment correlates with the subdivisions of subgenus *Zygophyllum* where species with simple leaves are placed together in § *Paradoxa* (Huysst. 1937). The separation of the species in this section is further confirmed by the wings present on their young stems as well as the similarities in the structure of their nectar discs (Table 7.2). § *Annua* Engl.(1915) is reinstated and now comprises three species, *Z. simplex* , *Z. spongiosum* and *Z. inflatum* (Table 7.1). The three species differ substantially from all other *Zygophyllum* species. Firstly, they are annual or at most biennial species, which is unique for *Zygophyllum* in southern Africa, although many annual or herbaceous *Zygophyllum* species occur in Australia (Eichler 1981). Secondly, *Z. simplex* and its allies have sessile, simple leaves whereas all other species in § *Bipartita* have petiolate, bifoliolate leaves. Thirdly, their leaf anatomy differs and a centric arrangement of leaf tissues is found in contrast to the isolateral or dorsiventral arrangement found in the species of § *Bipartita*. Fourthly, *Z. simplex* is the only species of *Zygophyllum* that displays the Krantz anatomy of the leaves, which is an indication of the specialized C4 method of photosynthesis. All three species in § *Annua* have a slightly capitate stigma. Lastly, when immersed in water, their seeds produce an unstructured, jelly-like mucilage in contrast to all other *Zygophyllum* species which produce a structured mucilage with spiral inclusions. The above mentioned characters justify the removal of *Z. simplex* from § *Bipartita* Huysst. and placing it and its allies in the reinstated § Annua.

Seventeen new species are described, illustrated and included within the relevant sections.

THE SUBDIVISION OF THE GENUS ZYGOPHYLLUM

Up to now, the subgenus *Agrophyllum* is considered to be the ancestral group of the genus *Zygophyllum.* Although I am not totally convinced of its status as such, I will stay with this arrangement until more extensive results are available.

SUBGENUS AGROPHYLLUM (Neck.) Endl.

§ Annua Engl.

7.1 *Z. simplex* L.

7.2 *Z. spongiosum* Van Zyl sp.nov.

7.3 *Z. inflatum* Van Zyl sp.nov.

***§ Prismatica* Van Zyl**

7.4 *Z. prismatocarpum* Sond.

7.5 *Z. patenticaule* Van Zyl stat. nov.

7.6 *Z. pterocaule* Van Zyl sp. nov

***§ Bipartita* Huysst.**

7.7 *Z. applanatum* Van Zyl sp. nov.

7.8 *Z. clavatum* Schltr. & Diels

7.9 *Z. cylindrifolium* Schinz

7.10 *Z. segmentatum* Van Zyl sp. nov.

7.11 *Z. tenue* Glover

7.12 *Z. retrofractum* Thunb.

7.13 *Z. chrysopteron* Retief

7.14 *Z. turbinatum* Van Zyl sp.nov.

7.15 *Z. decumbens* Del. var. *decumbens*

***§ Alata* Huysst.**

subsection *Alata*

7.16 *Z. microcarpum* Cham.

7.17 *Z. rigidum* Schinz

7.18 *Z. longistipulatum* Schinz

***§ Cinerea* Huysst.**

7.19 *Z. longicapsulare* Schinz

7.20 *Z. giessii* Merxm. & A.Schreib.

§ *Grandifolia* Engl.

7.21 *Z. stapffii* Schinz

SUBGENUS ZYGOPHYLLUM

§ *Paradoxa* Huysst.

7.22 *Z. cordifolium* L.f.

7.23 *Z. fusiforme* Van Zyl sp.nov.

7.24 *Z. orbiculatum* Welw. ex Oliver

§ *Capensia* Engl.

leaves sessile, terete

7.25 *Z. teretifolium* Schltr.

7.26 *Z. botulifolium* Van Zyl sp. nov.

leaves sessile, linear

7.27 *Z. spinosum* L.

7.28 *Z. pygmaeum* Eckl. & Zeyh.

7.29 *Z. rogersii* Compt.

leaves sessile, obovate/other

7.30 *Z. divaricatum* Eckl. & Zeyh.

7.31 *Z. namaquanum* Van Zyl sp. nov.

7.32 *Z. sessilifolium* L.

7.33 *Z. spitskopense* Van Zyl sp. nov.

7.34 *Z. cuneifolium* Eckl. & Zeyh.

7.35 *Z. hirticaule* Van Zyl sp. nov.

7.36 *Z. calcicola* Van Zyl sp. nov.

7.37 *Z. fulvum* L.

7.38 *Z. porphyrocaule* Van Zyl sp. nov.

7.39 *Z. swartbergense* Van Zyl sp. nov.

7.40 *Z. fuscatum* Van Zyl sp. nov.

7.41 *Z. flexuosum* Eckl. & Zeyh.

leaves petiolate

7.42 *Z. lichtensteinianum* Cham.

7.43 *Z. incrustatum* Sond.

7.44 *Z. maritimum* Eckl. & Zeyh.

7.45 *Z. debile* Cham.

7.46 *Z. cretaceum* Van Zyl sp. nov.

7.47 *Z. foetidum* Schrad. & Wendl.

7.48 *Z. macrocarpon* Retief

7.49 *Z. maculatum* Ait.

7.50 *Z. schreiberanum* Merxm. & Giess

7.51 *Z. leptopetalum* Sond.

leaves petiolate or sessile

7.52 *Z. pubescens* Schinz

7.53 *Z. leucocladum* Diels in Schultze

§ *Morgsana* Huysst.

7.54 *Z. morgsana* L.

CHAPTER 7

TAXONOMIC TREATMENT

Zygophyllum L.*Species Plantarum 1 : 385 (1753); DC.: 705 (1824); Sond.: 355 (1860); Bentham & Hooker f.: 226 (1862); Schinz: 55 (1888); Schinz: 188 (1894); Engl.: 10 (1896); Engl.: 80 (1899); Schlechter & Diels in Schultze: 705 (1907); Schlechter & Diels: 150 (1910); Engl.: 731 (1915); Engl.: 160 (1931); Huysst.: 59 (1937); A.Schreib.: 49 (1963); A.Schreib. in Merxm.: 1 (1966).

* Literature concerning southern African *Zygophyllum* only.

TYPE SPECIES: *Zygophyllum fabago* L. Sp. Pl. 1.: 385 (1753), according to Hitchcock & Greene, Intern. Bot. Congr. Cambridge, Nomencl. Proc. Brit. Bot.: 153 (1929).

Etymology: *Zygos*, Greek for joined or yoked, *phyllum*, Latin for leaf, referring to the many *Zygophyllum* species with bifoliolate or paired leaves.

Agophyllum Neck., Elementa botanica: 227, nr. 967 (1790); ? err. typogr., non rite publ.

Agrophyllum Endl., Genera plantarum .....: 1164 (1841).

Fabago Adans., Familles des plantes: 2 : 507 (1763).

Roepera A. Juss., Mem. Mus. Hist. Nat.: 12 : 434 (1815).

Sarcozygium Bunge, Linnaea: 17 : 7 (1843).

Miltianthus Bunge, Arbeit. Naturforsch. Ver. Riga: 1 : 197 (1897).

Currently all five genera are synonyms of which only the first two are relevant in the treatment of the southern African *Zygophyllum* species. *Agrophyllum* and *Fabago* form the basis of the two subgenera *Agrophyllum* and *Zygophyllum* respectively.

Decumbent or erect, many-stemmed shrublets or shrubs reaching heights of ca. I m and diameters of 1.5 m or scrambling into and over nearby plants and reaching heights of ca. 2 m and diameters of several meters, rarely prostrate, herbaceous annuals; branches sometimes jointed, indumentum consisting of unicellular hairs sometimes present either as white, two-armed, appressed hairs or as erect, twisted sparse or dense hairs, rarely glandular. *Leaves* opposite, simple or bifoliolate,

sessile or petiolate, often fleshy, usually drought deciduous; leaflets variable in shape, usually small, rarely large; stipules interpetiolar or free, variable in shape, membranous, herbaceous or spinescent, caducous or semi-permanent. *Flowers* solitary or rarely cymose. *Calyx* of (4-) 5 sepals, succulent, cucullate, free and articulate or membranous and slightly connate at base, persistent or deciduous, quinqunciate. *Petals* (4-) 5, white, cream or light to rich yellow or light orange, variable in shape, widely obovate, suborbicular or elliptic or spathulate, marked at base with various M-,U-,V-shaped blotches or streaked with red veins or without marks, with a long or short claw, imbricate. *Disc* fleshy, intrastaminal, smooth or papillate, 8–10 angled or variously lobed. *Stamens* 8–10, in two whorls, inserted at base of disc; filaments terete; staminal scales simple or 2-partite, adnate to ventral side of filament, variable in shape, when simple, usually with lacerated margins and sometimes with a border of papillae or a papillate surface, when biparted, always with entire margins, without papillae and with oblong segments. *Ovary* sessile on the disc, glabrous, rarely hairy or globulate, (4-) 5-locular, lobed or angled or globose, ovules pendulous, few to many in each locule; style terete, simple; stigma simple, rarely capitate. *Fruit* a spheroid, (4-) 5-ridged, -lobed, -parted or -winged capsule or schizocarp or septifragal fruit; seeds with or without endosperm, usually mucus producing; embryo straight, rarely slightly curved.

Subdivision of *Zygophyllum*

ZYGOPHYLLUM			
SUBGENUS AGROPHYLLUM		SUBGENUS ZYGOPHYLLUM	
§ *Annua*	3 species	§ *Paradoxa*	3 species
§ *Prismatica*	3 species	§ *Capensia*	*29 species*
§ *Bipartita*	9 species	leaves sessile / terete or linear	
§ *Alata*; subs. *Alata*	3 species	leaves sessile / obovate, other	
§ *Cinerea*	2 species	leaves petiolate	
§ *Grandifolia*	1 species	leaves petiolate / sessile	
		§ *Morgsana*	1 species

Key to the subgenera *Zygophyllum* and *Agrophyllum:*

1a Petals usually marked at base, nectar disc always papillate,
fruit a loculicidal capsule, disintegrating when mature,
seed arillate.....subgenus *Zygophyllum*

1b Petals never marked at base, nectar disc smooth,
fruit a septicidal schizocarp dividing in five mericarps,
seed without an aril, attached by a funicle.....subgenus *Agrophyllum*

Subgenus *Agrophyllum* (Neck.) Endl., Genera Plantarum: 1164 (1841); Bentham & Hooker f.: 226 (1862); Engl.: 12 (1896); Engl.: 81 (1899); Huysst.: 59 (1937); El Hadidi: 321 (1975); El Hadidi: 49 (1978).
Necker's generic citation is given as *Agophyllum*, and the first "correct" use as *Agrophyllum* is by Endlicher, Genera Plantarum, 1614 (1841). It is not clear whether the spelling *Agophyllum* is a typographical error or intentional, but at any rate Necker's genus is regarded as not validly published (IBCN).

Young stems round in cross section, or with a ventral groove or winged in a vertical plane (Figure 3.1); indumentum when present, consisting of two-armed, t-shaped, unicellular, appressed trichomes; stipules usually free, rarely fused; flowers usually solitary but sometimes arranged in a scorpioid cyme; sepals succulent, often cucullate and always articulate, petals without markings at the base, usually white, rarely yellow or pale orange, with a long claw at base; staminal scales usually bipartite to near the base or simple, or simple and enfolding each alternate filament; nectar disc always smooth and of Types 2—4 (Table 3.4); ovary sometimes hairy or globulate; fruits 5-locular, schizocarpic, dehiscing septicidally into 5 mericarps, either 5-lobed, 5-parted or 5-winged in combination with various shapes from spherical to prismatic, often succulent (Table 3.6); seeds small, pyriform, compressed pyriform, when immature attached with a thin, long funicle, usually many per locule, when immersed in water producing mucilage of a structured type, containing short, spiral inclusions which unravel apically, resembling a wine glass in side-view, or producing unstructured, jelly-like mucilage (Table 3.7).

Key to the sections of subgenus *Agrophyllum*:

1a Annual or biennial shrublets.....§ *Annua*
1b Perennial shrubs 2

2a Young stems winged.....§ *Prismatica*
2b Stems not winged.....3

3a Staminal scales simple, apex truncate, alternately enfolding a filament, fruits winged.....§ *Alata* subsect. *Alata*
3b Staminal scales simple or bipartite, apex not truncate, nor alternately enfolding a filament.....4

4a Staminal scales bipartite.....§ *Bipartita*
4b Staminal scales not bipartite.....5

5a Indumentum of two-armed hairs present.....§ *Cinerea*
5b Glabrous shrub with large, subrotund leaflets.....§ *Grandifolia*

§ *Annua* Engl. in Pflanzenwelt Afrikas 3,1 : 731 (1915); Engl.: 162 (1931).

Type species: *Z. simplex* L.

Diagnostic features

Annual or biennial, erect or prostrate herbs

Young stems with a prominent ventral groove

Leaves opposite, simple, sessile, younger leaves opposite branches

Stigma capitate

Nectar disc smooth, prominently 10-lobed, lobes arranged in 5 pairs, each pair orientated outwards and upwards

Staminal scales 10, biparted almost to the base

Fruit a schizocarp, dividing septicidally in 5 mericarps, later

splitting open along a dorsal suture

Mucilage unstructured, jelly-like

Van Huyssteen (1937) included *Z. simplex* in her original description of § *Bipartita* because of its bipartite staminal scales, although *Z. simplex* was the only herbaceous species amongst shrubby perennials. I regard *Z. simplex* , together with two closely related new species, *Z. inflatum* and *Z. spongiosum,* better placed in a section of their own. These three species differ substantially from all other *Zygophyllum* species. Firstly, they are annual or at most biennial species. This is unique for *Zygophyllum* in southern Africa, although many annual or herbaceous *Zygophyllum* species occur in Australia (Eichler 1981). Secondly, their leaf anatomy differs in several ways. The stomatal cells in the leaves are level with the surface, whereas those of other species are deeply sunken (Kuun 1997). They lack dendrites or druses within the leaves, whereas all the other species in subgenus *Agrophyllum* display them. Their leaves have a centric arrangement of tissues with a single layer of palisade cells below the epidermis, whereas the leaves of other species in the § *Bipartita* have an isolateral or dorsiventral arrangement with either two or more layers of palisade cells or with undifferentiated mesophyll. The lateral veins of *Z. simplex* display bundle sheaths with a Krantz-formation, indicative of the C4 pathway of photosynthesis, the only known species of *Zygophyllum* with this special way of photosynthesis (Sheahan & Cutler 1993, physiological evidence found in material from northeastern Africa; Kuun 1997, anatomical evidence found in material from southwestern Africa). Thirdly, Saleh & El Hadidi (1977) reported that the chemistry of *Z. simplex* differs somewhat from that of other *Zygophyllum* species. Fourthly, when immersed in water, their seeds produce an unstructured, jelly-like mucilage, quite unlike the structured mucilage with spiral inclusions produced by all other *Zygophyllum* species. Fifthly, *Z. simplex* and its allies have sessile, simple leaves whereas all other species in § *Bipartita* have petiolate, bifoliolate leaves. The above mentioned characters justify the removal of *Z. simplex* from § *Bipartita* and placing it and its allies in the reinstated § *Annua* Engl. This section now comprises three species, *Z. simplex* and its allies, *Z. spongiosum* and *Z. inflatum.* Table 7.1 summarizes the characters of the species in § *Annua.*

Key to the species in § *Annua*:

1a Erect annual or biennial herb, reaching a height of 0.3 m, mature fruit 5-parted, broadly obovoid, breaking up in 5 inflated mericarps with thin, smooth and glossy exocarp ....*Z. inflatum*

1b Prostrate or semi-erect annual or biennual herb, reaching a height of at most 0.1 m, mature fruit 5-parted, polymorphic in shape, breaking up in 5 mericarps which either have a thick, spongy exocarp without dark tubercles or a thin, translucent exocarp with many dark tubercles arranged in rows or scattered along its outer margins.....2

2a Mature fruits 5-parted, spheroid, 1.5–1.8 x 2.5–3.5 mm, breaking up in 5, semi-circular, small mericarps which have a thick, spongy exocarp without dark tubercles along its outer margins.....*Z. spongiosum*

2b Mature fruits 5-parted, polymorphic in shape, obovoid, spheroid or obcordate, 2.5–5.5 x 2–3 mm, breaking up in 5 mericarps which have a translucent exocarp with many, dark tubercles arranged in rows or scattered along its outer margins..... .....*Z. simplex*

Table 7.1. Characters of the species in § *Annua*

Z. SIMPLEX	**Z. SPONGIOSUM**	**Z. INFLATUM**
prostrate herb, height at most 0.1 m	prostrate herb, height at most 0.1 m	erect herb, height 0.3 m
leaves succulent, obovoid or globose, 4.0–12.0 x 1.5–4.0 mm	leaves succulent, obovoid or globose, 6–11 x 2–3 mm	leaves succulent, obovoid or globose, 2–11 x 2–3 mm
stipules triangular, 2 ventral and 2 dorsal	stipules triangular, 2 ventral and 2 dorsal	stipules triangular, 2 ventral and 2 dorsal

petals spathulate, yellow, 3.0–4.0 x 0.5–2.0 mm	petals spathulate, white or yellow, 2.5 x 0.8–1.0 mm	petals spathulate, yellow, 4.5 x 1.5 mm
stigma capitate	stigma capitate	stigma capitate
staminal scales bipartite, filament to scale ratio 3 : 1	staminal scales bipartite, filament to scale ratio 3 : 1	staminal scales bipartite, filament to scale ratio 3 : 1
fruit shape variable, succulent when fresh, when dry obovoid to obcordate	fruit spheroid, not succulent	fruit broadly obovoid, not succulent
mericarps thin walled with many dark tubercles	mericarps semi-circular with thick, spongy exocarp, never with dark tubercles	mericarp inflated with thin, smooth, glossy exocarp, never with dark tubercles
mericarps 1—9-seeded	mericarps 1or 2-seeded	mericarps 2—4-seeded

7.1 Zygophyllum simplex *L.* Mantissa plantarum: 8 (1767); Lam.: 441 (1786); Willd.: 560 (1799); Pers.: 463 (1806); DC.: 706 (1824); Sond.: 357 (1860); Oliver: 285 (1868); Schlechter & Diels in Schultze: 705 (1907); Chiov.: 110 (1929); Huysst.: 60 (1937); H. Perrier: 284 (1950); H. Perrier: 6 (1952); Ozenda & Quézel: 68 (1956); A.Schreib.: 100 (1963); A.Schreib. in Merxm.: 18 (1966); El Hadidi in Täckholm: 309, pl. 99D (1974); El Hadidi: 64 (1978); Hepper & Friis: 248 (1994). TYPE - Egypt: Cairo or Yemen: Wadi Mawr, Ghurab ("Môr, Ghorab"), 1762–1763, *Forsskål s.n.* (C-Forsskål, lecto!, designated here).

Zygophyllum portulacoides *Forssk.*: 88, t. 12B (1775); non Cham.: 50 (1830). TYPE - Egypt: Cairo or Yemen: Wadi Mawr, Ghurab ("Môr, Ghorab"), 1762–1763, *Forsskål s.n.* (C-Forsskål, holo!).

Zygophyllum simplex *L.* var. **capense** *Sond.*: 357 (1860); A. Schreib.: 100 (1963); A. Schreib. in Merxm.: 18 (1966). Type - Clayey soil in Bosjesmansland, at the Orange River, *Ecklon & Zeyher 771* (SAM, lecto!, designated here, TCD!).

Zygophyllum simplex *L.* var. **namaense** *Schinz:* 188 (1890); Dinter: 210 (1928). TYPE - Namibia: Cannas, *Schinz 230,* (Z, lecto!, designated here); Bethanien, *Schenck 316* n.v.

Zygophyllum microcarpum *Cham.* var **prostratum** *Sond.* 363 (1860); TYPE: Limoenfeld, Winterveld, 3000–4000 f. *Drège s.n.* (S!, annotated by Sonder, lecto., designated here, TCD!).

Zygophyllum obtusum *Vicary*: 367 (1848), nom nud.

Misidentifications: *Zygophyllum portulacoides* sensu Chamisso is in fact *Miltianthus portulacoides*; *Zygophyllum microphyllum* sensu Ecklon & Zeyher 771 (SAM!, TCD!); *Zygophyllum microcarpum* E.Mey. in Drège*:* 92 : (1843), *Drège 3181* (P!); *Drège s.n.*, Orangerivier, Gariep Verleptpram (TCD!); *Drège 1038* (K!).

Herbaceous, succulent annual or biennial, usually prostrate, forming dense mats, sometimes with erect stem tips at the periphery or resprouting from the center, reaching a height of up to 0.1 m and a diameter of 1.0 m. *Stems:* old stems usually prostrate, green, red, yellow or cream coloured, smooth, when dry often displaying numerous embedded crystals resulting in a warty surface; young stems green or yellow, leafy, with a prominent ventral groove. *Leaves* sessile, green or yellowish, simple, narrow to broadly obovoid or nearly globose, oldest few leaves opposite, younger leaves opposite a branch, succulent, 4.0–12.0 x 1.5–4.0 mm, apex round, base cuneate; stipules triangular, membranous, margins sometimes lacerated, two each on ventral and on dorsal sides of stems, semi-permanent, 1.0–2.0 x 0.5–1.0 mm. *Flowers* solitary or 2 together, axillary. *Pedicel* 2—3 mm long. *Sepals* 5, ovate or obovate, membranous margined, outer ones with a succulent, cuculate apex, 1.5–2.5 x 1.0 mm. *Petals* 5, spathulate, 3.0–4.0 x 0.5–2.0 mm, apex round, base with long claw, yellow. *Nectar disc* fleshy, smooth, prominently 10-lobed, lobes arranged in 5 pairs, each pair orientated outwards and upwards. *Stamens* 10, in two whorls; filaments terete, 3—3.5 mm long; staminal scales 10, alternately differently orientated, bipartite almost to the base, each segment ovate or oblong, apex rounded or obliquely lobed, margins entire, base narrowed, 1.0 x 0.3–0.5 mm, ± 1/3 the length of the filament. *Ovary* obovoid, 5-parted; style terete; stigma capitate. *Fruit* a 5-parted, septicidal schizocarp variable in shape, 2.5–5.5 x 2–3 mm, succulent when fresh, narrowly to broadly obovoid, spherical or obcordate, with or without a deep or wide sinus, breaking up in 5 mericarps when dry, each with thin,

nearly transparent walls, displaying dark tubercles, scattered or in several rows, as well as a central ridge or groove arranged longitudinally along its outer walls, also able to spit open along this ridge or groove. *Seed* pyriform, 2—9 per mericarp, 0.8–1 x 0.3–0.5 mm, brown, farinous, when immature attached with long funicle, testa granular, becoming nearly transparent when placed in water and producing clouds of structureless, jelly-like mucilage that floats away (Figures 7.1.1—2).

Diagnostic features and affinities

Z. simplex is distinguished by its herbaceous nature, by its mat forming ability (Figure 7.1.1.A) and by its fruits that are succulent when fresh (Figures 7.1.1.B; 7.1.2.A), and when dry break up in 5 mericarps each with thin, nearly transparent walls with scattered, dark tubercles or with several rows of dark tubercles arranged longitudinally along its outer margins (Figure 7.1.2.B—D). The mericarps vary in size and shape though, and can be narrowly or widely obovoid, spherical or obcordate (Figure 7.1.2.C and E). *Z. simplex* is allied to *Z. spongiosum* and *Z. inflatum,* also herbaceous annuals or at most biennials and which have similar succulent, obovoid, sessile, simple leaves arranged in a similar way. The leaves of *Z. simplex* display bundle sheaths with Krantz-formation around lateral veins. It is the only known *Zygophyllum* sp. with this arrangement (Sheahan & Cutler 1993, Kuun 1997). The single layer of palisade cells present beneath the epidermis of all three species causes a distinct reticulated pattern on the surface of their dry leaves.
These three species can be distinguished by the differences in their fruit structure. The fruits of *Z. simplex* are described above. The fruits of *Z. spongiosum* are spherical and have semi-circular mericarps with prominently spongy outer walls. The fruits of *Z. inflatum* are broadly obovoid and have inflated mericarps with thin, smooth, glossy walls. *Z. simplex* and *Z. spongiosum* have a prostrate or decumbent habit reaching heights of at most 0.1 m and diameters of 1.0 m, whereas *Z. inflatum* grows upright, reaching a height of 0.3 m and a diameter of 0.5 m. Table 7.1 summarizes the characters of species in § *Annua*.
The epithet *simplex* probably refers to its simple leaves.

Distribution and ecology

A

B

C

D

Figure 7.1.1. *Z. simplex*, A, *Van Zyl 3772*; B and D, *Van Zyl 4315*; C, *Van Zyl 4337*. A, prostrate, mat forming habit; B, immature, succulent fruits displaying faint rows of tubercles along outer margins of mericarps; C, yellow colour and semi-erect habit displayed during periods of water stress; D, twigs with globous, succulent leaves, yellow flowers and succulent as well as dry fruits.

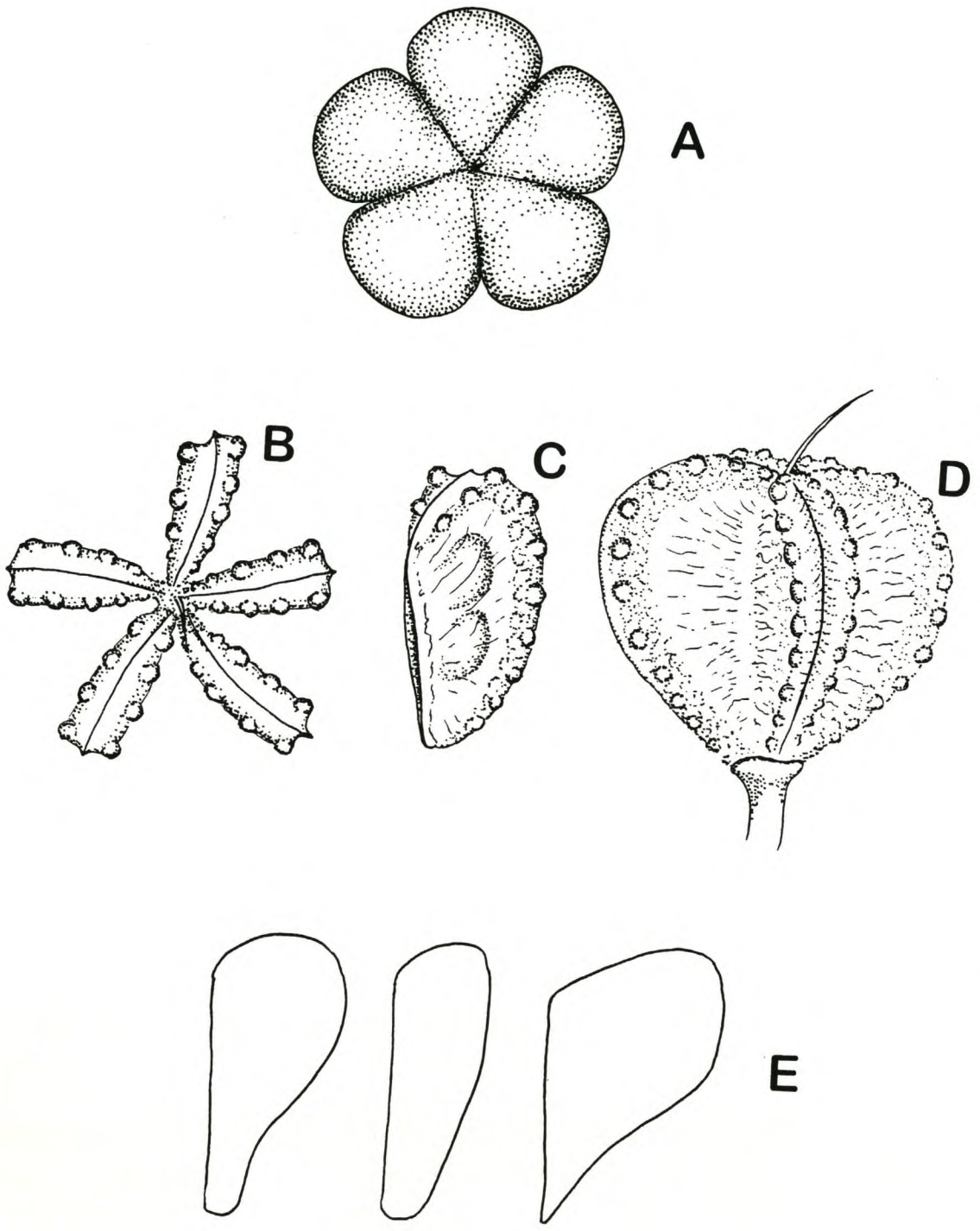


Figure 7.1.2. *Z. simplex, Van Zyl 3825.* A, top-view of fresh, succulent fruit; B, top-view of dry, mature fruit; C, side-view of a single mericarp; D, side-view of mature, dry fruit; E, side-view of several mericarps to illustrate the variation found in mericarp shape.

Z. simplex is widespread in the arid, north-western and southern parts of Namibia and the Northern Cape Province of South Africa. Outlyer populations occur near Rakops in central Botswana, the Senekal area in the Free State and around Aberdeen in the Eastern Cape (Figure 7.1.3). In Namibia it occurs in vegetation classified as **Desert Biome, Succulent Karoo Biome, Nama Karoo Biome** and in **Savanna Biome** (Irish, 1994). These Biomes receive rain during winter (closer to the coast) and in summer (further inland) and in some areas also throughout the year. In South Africa it is found in the **Savanna Biome**: Kimberley Thorn Bushveld (Van Rooyen & Bredenkamp 1996); **Grassland Biome**: Moist Cool Thorn Bushveld (Van Rooyen & Bredenkamp 1996); **Nama Karoo Biome**: Bushmanland Nama Karoo; Orange River Nama Karoo; Eastern Mixed Nama Karoo (Hoffman 1996); and **Succulent Karoo Biome**: Upland and Lowland Succulent Karoo (Hoffman 1996). These Biomes receive rain, some during winter or summer months and some throughout the year. It seems clear that *Z. simplex* is able to adapt to very different conditions as found in the Biomes of southwestern Africa as well as in other Biomes found in the northeastern African area.

A question to be answered is how this herbaceous, annual species, with soft and succulent leaves, manages to survive under these different conditions. A probable answer could be the bundle sheaths with Krantz-formation found around its lateral veins in its leaves and the associated C4 photosythesis. The C4 method of photosynthesis is an advanced type probably enabling this species to invade new territories. A similar situation is found in *Tribulus terrestris*.

Populations of *Z. simplex* are large or individuals can be few and scattered over large areas. Substrates vary from shale flats, sandy gravel plains, red sands, "kalkvloere", brackish and moist pan edges, course, granitic sands, calcareous plains, sandy water courses to muddy river banks. *Z. simplex* is often found in disturbed spots. Its usual prostrate, mat forming habit (Figure 7.1.1.A) becomes semi-erect when water stress is experienced. When its growing season comes to an end, its branches often become semi-raised from the ground while a change of

colour occurs from green to khaki-green, yellow or even red which results in a semi-erect, bright yellow or even reddish, dry plant.

Flowers and fruits are found throughout the year. Flowers are sweet scented at night and are probably pollinated by ants, ladybirds and flying insects observed on plants. Grazing damage to *Z. simplex* is rare probably because of its bad taste (to humans). However, it supports the life cycles of numerous insects and arachnids in the Central Namib Desert (Wharton 1980). *Z. simplex* is unpalatable, is widespread and many of its populations are large, therefore it is not considered threatened at present.

Common names: patrysdruiwe, volstruisdruiwe, erdmanopslag, brakkies, brakspekbos, rankspekbos.

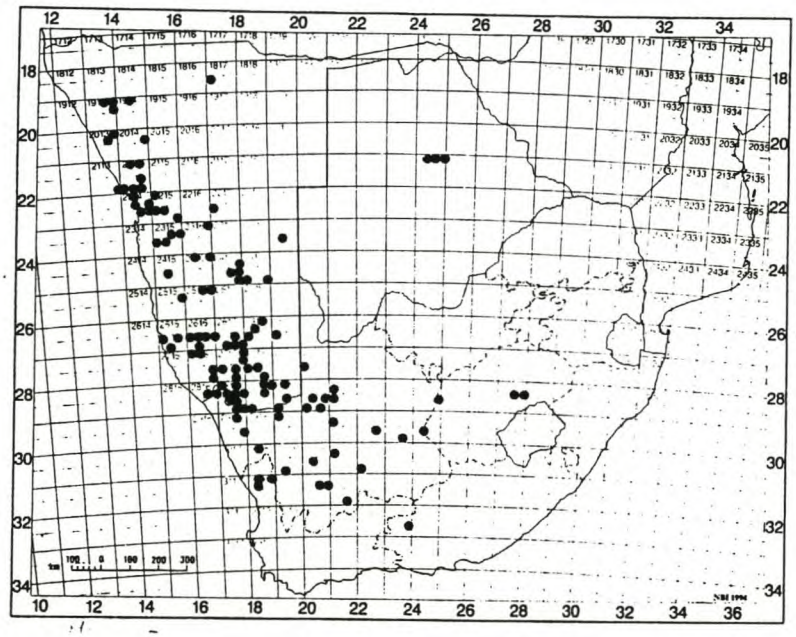


Figure 7.1.3. Geographical distribution of *Z. simplex*.

Specimens examined

–1817 (Tsintsabis): Onguma: OU 314 (–CA), *Walter 468* (WIND).

–1913 (Sesfontein): Hoanib valley flats (–BA), *Smith & Malan 304* (WIND); Between Hoanib oasis and Mowe Bay (–BB/BD), *Jankowitz 324* (WIND); Kwowarib Schlucht (–BD), *Rusch s.n.* (WIND 16205).

–1914 (Kamanjab): At Kamanjab Station on border of reserve (–AB), *Kers 1334* (WIND).

–2013 (Unjab Mouth): Sandy soil on Wêreldsend, Khorixas (–BB), *Theron 3816* (PRE); Koichab pump station (–BC), *Seely 2071* (WIND).

–2014 (Welwitchia): Welwitch (–BD), *Galpin 7635* (BOL, PRE, SAM).

–2113 (Cape Cross): At Cape Cross, 500 meter from coast (–DD), *Giess 8703*, 8703a (WIND); *Rand s.n.* (BOL 24958).

–2114 (Uis): Roadsides to Brandberg West Mine (–AB), *Craven 740* (WIND); Sonuseb gorge, Brandberg (–BA), *Craven 2172*, (WIND); Flats between Omaruru River and Cape Cross (–CC), *Jensen 210a* (WIND); 13 M from Hentiesbaai on road to Uis (–CD), *Tölken & Hardy 822* (WIND); 55 km NE of Hentiesbaai (–DA), Greuter 20307 (WIND); Sandy plains 63 km NE of Hentiesbaai on Uis road (–DA), *Goldblatt 1976* (NBG, WIND); 35 km E of Salzpad on marble - quarts ridge on N side of Omaruru (–DC), *Giess 7857* (WIND).

–2124 (Rakops): Pan edge, 32 km E of Rakops (–AB), *Wild & Drummond 7222* (GAB, PRE); Botletle river at Toromoja (–BA), *Ngoni 470* (GAB); Pan 2 M N of camp (–BA), *Anderson 156* (GAB, PRE); Boteti delta area, NE of Mopipi (–BB), *Fry 3* (PRE); W end of Chenkwanana pan (–BB), *Smith 3098* (GAB, PRE).

–2214 (Swakopmund): On N side of Omaruru river about 16 km E of Salzpad (–AB), *Giess 7847* (WIND); Vlotska Baken between Swakopmund and Cape Cross (–AD), *Kers 277* (WIND); Arandis area, W of town (–BD), *Craven 1707* (WIND); In dry, sandy bed of Swakop river, 22 km from Swakopmund (–DA), *Rodin 2143* (BOL); Swakopmund (–DA), *Keet 1713* (PRE); Rosen quarz Kuppe at Rossing (–DB), *Watt 67* (WIND); Goanikontes, Rossing Mountain (–DB), Kers 1294 (WIND).

–2215 (Trekkopje): 85 km NE of Swakopmund, near Usakos (–AA), *Greuter 20290* (WIND); Schakalswater (–CB), *Peter s.n.* (SAM 74797); Right side of Swakoprivier, along track from Swakop at Tsawichab to Nordenburg (–CA), *Kers 1536* (WIND); 18 M W of Donkerhuk: KAR 91 (–DD), *Ihlenfeldt, De Winter & Hardy 3055* (PRE, WIND).

–2217 (Windhoek): Windhoek (–CA), *Steyn 986* (NBG).

–2315 (Rostock): Near viewpoint on Kuiseb Canyon (–BC), *Phillipson 842* (PRE); In sand at bridge over Kuiseb (–BD), *Luedtke 616* (WIND); N side of Kuiseb Canyon in Namib Naukluft Park (–BD), *Van Zyl 3796* (NBG); Schliesen 483, near Gamsberg turn off (–BD), *Van Zyl 3798* (NBG); On high rocks at Kuiseb Canyon (–BD), *Chadwick 76* (PRE, WIND); Natab, 72 km inland on Kuisebrivier (–CA), *Keet 1713* (WIND); SE from Hope Mine, Kuisebrivier (–CB), *Kers 1571* (WIND).

–2316 (Nauchas): Hakskeenpan (–BB), *Van der Merwe 1420* (PRE).

–2319 (Aminuis): Edge of salt pan at Aminuis (–CB), *Thorne s.n.* (SAM 52661).

–2415 (Sossusvlei): W aspects of Tsaukhaub (–CB), *Hardy & Venter 4470* (WIND).

–2416 (Maltahohe): Naukloofberge at Bullspoort (–AB), *Strey 2087 and Rodin 2874* (BOL); *Strey 2087* (PRE); S of Maltahohe on Grootfontein/Lisbon 81 (–BB), *Van Zyl 3801* (NBG, PRE, WIND).

–2417 (Mariental): At Salzbrunn station, N of Mariental (–BD), *Van Zyl 3784* (NBG); Haribes, Mariental 18/19 (–DA), *Volk 12063* (WIND); Along roadside S of Mariental (–DB), *Banks 93* (PRE); Jakkalsfontein, 35 km S of Maltahohe on B1 (–DD), *Van Zyl 3781* (NBG).

–2418 (Stampriet): Asab river, 30 M SW of Stamprietfontein (–CC), *Loeb s.n.* (PRE s.n.); Naruchas on Auob river banks (–DD), *Codd 5873* (PRE, WIND).

–2515 (Awasib): Aandster 147, SW of Maltahohe (–BD), *Van Zyl 3817* (NBG, PRE, WIND); *Van Zyl 3816* (NBG).

–2516 (Helmeringhausen): Kleinfontein Nord 82, S of Maltahohe (–BA/BB), *Van Zyl 3804* (NBG).

–2615 (Luderitz): Luderitzbucht, at Höhe Friedhof (–CA), *Metz s.n.* (WIND 16167); Koichab valley, 10 M E of Pump station (–CA), *Logan 357* (WIND); W aspect of Diamantberg, Luderitz (–CD), *Giess & Van Vuuren 712* (PRE, WIND); Limy sand at Haalenberg (–DA), *Van Zyl 3867* (NBG, WIND).

–2616 (Aus): Grassy plains 19 km W of Aus (–CA), *Van Zyl 3864* (NBG, WIND); Aus (–CB), *Rogers 29562* (GRA); Kuibib 15 on Tsamvlakte, S of Aus (–CD), *Van Zyl 3882* (NBG, PRE, WIND); Farm Aar, on Aarrivier (–DA), *Wendt 160* (WIND); Kuibis (–DB), *Range 637* (BOL, SAM).

–2617 (Bethanie): Plains 4 km W of Goageb (–CD), *Van Zyl 3851* (NBG); Tschaunaup on the Fish river (–DA), *Gerstner 6350* (PRE); 20 km W of Seeheim (–DC), *Van Zyl 3846* (NBG, WIND); Near Naute (–DD), *Van Zyl 3844* (NG, WIND).

–2618 (Keetsmanshoop): Blaukehl Sud 142, NE of Keetmanshoop (–AD*), Van Zyl 3772* (NBG); Kalkvloere, past Khoexas (–BA), *Van Zyl 3773* (NBG, PRE); Keetmanshoop (– CA), *Acocks 15607* (PRE); *Pillans 6007* (BOL); Kokerboomwoud, 12 km NE of Keetmanshoop (–CA), *Van Zyl 3767* (NBG).

–2619 (Aroab): Zabubegas 305, 64 km W of Aroab (–CA), *Van Greuning 589* (PRE).

–2716 (Witputz): Tsaus Spinnenberg, in Diamandgebiet 1 (–AA), *Wendt 16/4* (WIND); W aspect of Tsausberg, Diamantgebiet 1 (–AA), *Wendt A/2* (WIND); SW aspect of Tsausberg in Tal innen (–AA), *Wendt C/12* (WIND); 106 km N of Rosh Pinah on road to Luderitz (–AB), *Leuenberger, Raus & Schiers 3278* (WIND); Arimas 83, NE of Rosh Pinah (–DB), *Van Zyl 4485* (NBG); Arimas/Kolke, NE of Rosh Pinah (–DB), *Van Zyl 4407* (NBG, WIND); Namuskluft, E of Rosh Pinah (–DD), *Van Zyl 4387* (NBG).

–2717 (Chamaites): River bed at bridge between Grunau and Keetmanshoop (–BB), *Ihlenfeldt 1826* (PRE); Plains between Holoog and Chamaites (–BB), *Van Zyl 3843* (NBG, WIND); Plains near junction of Ai-Ais with Holoog and Gorges road (–BD), *Van Zyl 3841* (NBG, WIND); State land 3 km S of Uitsig: LU 82 (–CA), *Wendt 38* (WIND); Near Fish river viewpoint (–DA), *Van Zyl 3839* (NG, PRE, WIND); Hobab, SE of Ai-Ais (–DA), *Van Zyl 3838* (NBG, PRE, WIND); Kwaggasnek, 20 km E of Ai-Ais (–DC), *Van Zyl 3834* (NBG, PRE, WIND).

–2718 (Grunau): Klein Karas (–CA), *Örtendahl 127* (PRE); *Pillans 5883* (BOL); Sandy roadside 7 km N of Grunau (–CB), *Goldblatt 1872* (NBG, WIND); Drift near Kanus Railway Station (–DC), *Wilman 269* (BOL, NBG, PRE); Sandy plains at Kanus Railway Station (–DC), *Van Zyl 3764* (NBG, WIND).

–2720 (Noenieput): Noenieput, Kalahari (–CA), *Martin 1147* (NBG).

–2816 (Oranjemund): Arisdrift, Orange River valley (–BC), *Williamson 2989* (BOL); At Skilpad in Diamond Area No. 1 (–BC), *Williamson 2547* (BOL); Khubus (–BD), *Metelerkamp 39* (BOL); Anniskop, NW of Khubus, Richtersveld (–BD), *Van Zyl 4138* (NBG); Between Bloeddrif and Anniskop (–BD), *Van Zyl 4070* (NBG); Cornellskop, W of Khubus, Richtersveld (–BD), *Van Zyl 4063* (NBG); *Van Jaarsveld, Forrester & Jacobs 8583* (NBG).

–2817 (Vioolsdrif): Between confluence of Boom and Dabimub rivers with Orange river (–AA), *Van Zyl 4337, 4476* (NBG, WIND); Gamkab river bed on Aussenkjer (–AD), *Muller 19* (WIND); Dry stream bed at Kanabeam on road to Ai-Ais (–BA), *Van Zyl 3829, 3830* (NBG, PRE, WIND); At Aussenkjer, ± 30 km NW of Noordoewer (–BC), *Moffett 1134* (NBG); Gemsbokberg, at S turn off from B1 towards

Ai-Ais (–BD), *Van Zyl 3827* (NBG); Between Noordoewer and Aussenkjer (–CB), *Van Zyl 4325* (NBG, WIND); Sandy flats at Vioolsdrift (–DA), *Thorne s.n.* (SAM 51586); At Vioolsdrift (–DA), *Eliovson s.n.* (PRE 697474); *Herre s.n.* (STE 1201112 in NBG); In Vyfmylspoort, S of Vioolsdrift (–DC), *Van Zyl 3825* (NBG, PRE, S, WIND); S of Vyfmylspoort (–DC), *Fellingham 1098* (NBG); Flats near Bleskop, Settlement area (–DD), *Le Roux 2880* (NBG); 20 km S of Vioolsdrift (–DD), *Wisura 3628* (NBG).

–2818 (Warmbad): 15 km S of Karasburg (–BA), *Van Zyl 3763* (NBG, WIND); Sides of Ham river and vlei, 55 M from Ariamsvlei on road to Karasburg (–BB), *Tölken & Hardy 607* (PRE, WIND); On large rocks in Warmbad (–BC), *Verdoorn & Dyer 1773* (WIND); *Galpin 14133* (PRE); *Schlechter s.n.* (STE 10767 in NBG); *Thorne s.n.* (SAM 35787); Hills at Vuurdood (–CC), *Schlechter 11450* (BOL, PRE).

–2819 (Ariamsvlei): Mountain valley near Onseepkans (–CB), *Jankowitz 229/1348* (WIND); Charle's Pass, Pelladrift road (–CC), *Wilson s.n.* (GRA 7402).

–2820 (Kakamas): Augrabies Falls (–CB), *Compton 24480* (NBG); *Zietsman 652* (PRE); 40 km W of Kakamas (–CC), *Van Zyl 4315* (NBG, PRE, S, WIND); Village entrance, Keimoes (–DB), *Van Zyl 4314* (NBG, PRE, S, WIND); *Barnard s.n.* (SAM 32366); 9 M ENE of Kakamas (–DC), *Leistner & Joynt 2817* (PRE).

–2821 (Upington): On main road between Upington and Kakamas (–AC), *Van der Schyff 6938* (PRE); Pavement in Upington (–AC), *Labuschagne s.n.* (NBG 120534); Upington (–AC), *Borcherds s.n.* (Marloth 13802 in PRE): Dyasonsklip between Upington and Keimoes (–CA), *Glover s.n.* (BOL 13347).

–2824 (Kimberley): Rietpan, Kimberley (–DB), *Wilman s.n.* (BOL 5913, TM 20246).

–2827 (Senekal): Biddulphs, 9 M N of Orange River (–BC/BD), *Anon* (BOL 1829).

–2917 (Springbok): Steinkopf (–BA), *Visser s.n.* (STE 31749 in NBG); Next to homesteads in O'Kiep (–DB), *Hugo 209* (NBG); At Kaip (–DB), *Rösh & Le Roux 268* (WIND).

–2919 (Pofadder): 5 km from Pella on Pofadder-Goodhouse road (–AA), *Glen 1466* (PRE); Plot in Pella (--AA), *Van Zyl 4323* (NBG).

–2921 (Kenhardt): Kenhardt (–AC), *Van Niekerk s.n.* (STE 10103 in NBG); 15 M S of Pofodder (–AC), *Schlieben 8966* (PRE); 77 M W of Kenhardt (–AC), *Schlieben 8883* (PRE).

–2922 (Prieska): Brak river banks 20 M from Prieska (–DA), *Bryant 1074* (PRE); *Bryant J100* (PRE); Near Prieska (–DA), *Bryant s.n.* (BOL 49243).

–2923 (Doublas): 6 km from Strydenburg on road to Prieska (–DC), *Herman 627* (PRE).

–2924 (Hopetown): Grange Railway Station (–CB), *Pole-Evans H11599* (PRE); *Moran s.n.* (PRE 45808, PRE 45810).

–3018 (Kamiesberge): Granite pavement, Stofkloof (–AB), *Schelpe 8223* ((BOL).

–3019 (Loeriesfontein): Slaty flats on Kamdanie, SW of Loeriesfontein (–CD), *Snijman 999* (NBG, PRE).

–3020 (Brandvlei): 12 M SW of Brandvlei (–CB), *Wisura 2010* (NBG); On saline Karoo near Brandvlei (–CC), *Watermeyer s.n.*(PRE 7787).

–3021 (Vanwyksvlei): Hartogskloof, halfway between Vanwyksvlei and Brandvlei (–AC), *Thompson 3125* (NBG).

–3118 (Vanrhynsdorp): Sandy flats of Bitterfontein, over Kammas to Lieslap (–AB), *Zeyher 280* (PRE); Roadsides between Nuwerus and Lutzville (–AD), *Coetzer 861* (PRE); Next to Sishen railway line crossing with Doringrivier (–BB), *Van Zyl 4584* (NBG, PRE).

–3120 (Williston): 30 M W of Williston (–BC), *Theron 1443* (PRE); Near gate to Williston Station (–BD), *Smith 2448* (PRE); Heeltevrede, 14 km W of Williston (–BD), *Powrie 870* (NBG); Sandy places in Williston area (–BD), *Schmidt 156* (PRE).

–3121 (Frazerburg): On plains near Frazerburg (–DC), *Bolus 3278* (BOL).

–3223 (Rietbron): S of Aberdeen on road to Willowmore (–DB), *Dyer 1929* (GRA).

No precise or unknown locality: Without locality, *Thunberg s.n.* (UPS); Sandy Namib desert plains near Dupas river, Damaraland, *Marloth 1305* (PRE); Namib river E of Walvisbaai, *Jensen s.n.* (STE 31747 in NBG); Sandy plain near Nautilis, Luderitz, *Kinges 2679* (PRE); 6 M N of Abiam, Cape Province, *Pole-Evans 2149* (PRE); Ex Hort STE, *Herre s.*n. (BOL 49371); In mud at bottom of hills along Orange River in Bushmanland, *Eckon & Zeyer 771* (Z. microphyllum L.) (SAM); Felsflora south of Luderitzbucht, *Range s.n.* (SAM s.n.); Between Aus and Orange River, *Schenk 316* (Z); Between Grauwater and Klipplaat, Cape Province, *Pearson 3278* (NBG); Towards the Groote River from Aberdeen, *Hutchinson 3137* (LISC); Karasberg, *Filipini s.n.* (GRA 7401); 90 M W of Middelburg, *Comins 619* (PRE); Flats on Walkraal, Williston, *Foley 197* (PRE).

7.2 Zygophyllum spongiosum *Van Zyl,* sp. nov. (§ *Annua) Z. simplicis* et *Z. inflati* affinis propter habitum mollem annuum vel biennem [foliaque simplicia], sed mericarpiis crassis spongiosis; mericarpia *Z. simplicis* parietibus laevibus paene translucidis, seriebus tuberculorum obscurorum; mericarpia *Z. inflati* nitida inflata, parietibus tenuibus. TYPE - Namibia: Rietfontein, Etosha Pan, *Van Zyl 4492* (NBG, holo, PRE, S, WIND)

Z. simplex sensu Zohary: 254, pl. 367 (1972).

Herbaceous, succulent annual or biennial, mostly prostrate, forming dense mats, sometimes with erect branch tips at periphery or resprouting from the center, reaching a height of up to 0.1 m and a diameter of 1 m. *Stems:* old stems green, red, yellow or cream coloured, smooth when fresh, when dried usually displaying numerous embedded crystals resulting in a warty surface; youngest stems green or yellowish, leafy, with a prominent ventral groove. *Leaves*: oldest leaves opposite, younger leaves opposite a branch, this arrangement alternating on stems, sessile, narrow to broadly obovoid or nearly globose, succulent, apex and base obtuse, 6—

11 x 2—3 mm; stipules triangular, membranous, margins sometimes lacerate, two each on ventral and on dorsal sides, 1 x 0.5–1 mm, semi-permanent. *Flowers* solitary or 2 together, axillary. *Pedicel* 2—3 mm long. *Sepals* 5, ovate or obovate, membranous margined, outer ones with a succulent, cucullate apex, 1.5–2.0 x 1.0 mm. *Petals* 5, spathulate, apex round, base with long claw, white or yellow, 2.5 x 0.8–1.0 mm. *Nectar disc* fleshy, smooth, prominently 10-lobed, lobes arranged in 5 pairs, each pair orientated outwards and upwards. *Stamens* 10, in two whorls; filaments terete, 3 mm long; staminal scales 10, alternately differently orientated, bipartite almost to the base, each segment ovate or oblong, apex rounded or obliquely lobed, apex rarely lacerate, lateral margins entire, base asymmetrical, 1 x 0.3 mm, ± 1/3 the length of the filament. *Ovary* spherical, 5-parted, covered with spongy epidermal cells, dark tubercles rarely present; style terete; stigma capitate. *Fruit* a 5-parted, septicidal schizocarp, spherical,1.5–1.8 x 2.5–3.5 mm, breaking up in 5, semi-circular mericarps each with a ventral opening, thin side walls and thick, spongy outer walls, sometimes displaying a longitudinal, central ridge or groove in outer wall, splitting also along the dorsal suture, dark tubercles absent on mature mericarps. *Seed* pyriform, 1—2 per mericarp, 0.8—1.3 x 0.5 mm, brown, when immature attached by a long funicle, testa granular, farinous, when placed in water becoming nearly transparent and producing a structureless, jelly-like mucilage (Figure 7.2.1).

Diagnostic features and affinities

Z. spongiosum is distinguished by its herbaceous habit, by its mat forming ability and by its spherical, 5-parted fruits which separate into 5 semi-circular mericarps. These mericarps have prominently spongy outer walls (hence the epithet *spongiosum* which is Latin for sponge). *Z. spongiosum* is allied to *Z. simplex* and *Z. inflatum* which are also herbaceous annuals or at most biennials and which have similar, succulent, obovoid, simple leaves arranged in a similar way. The single layer of palisade cells found underneath the epidermis of all three species causes a distinct reticulate pattern on the surface of dry leaves.

These three species are distinguished by differences in fruit structure and habit. The fruits of *Z. spongiosum* are spherical and have semi-circular mericarps with

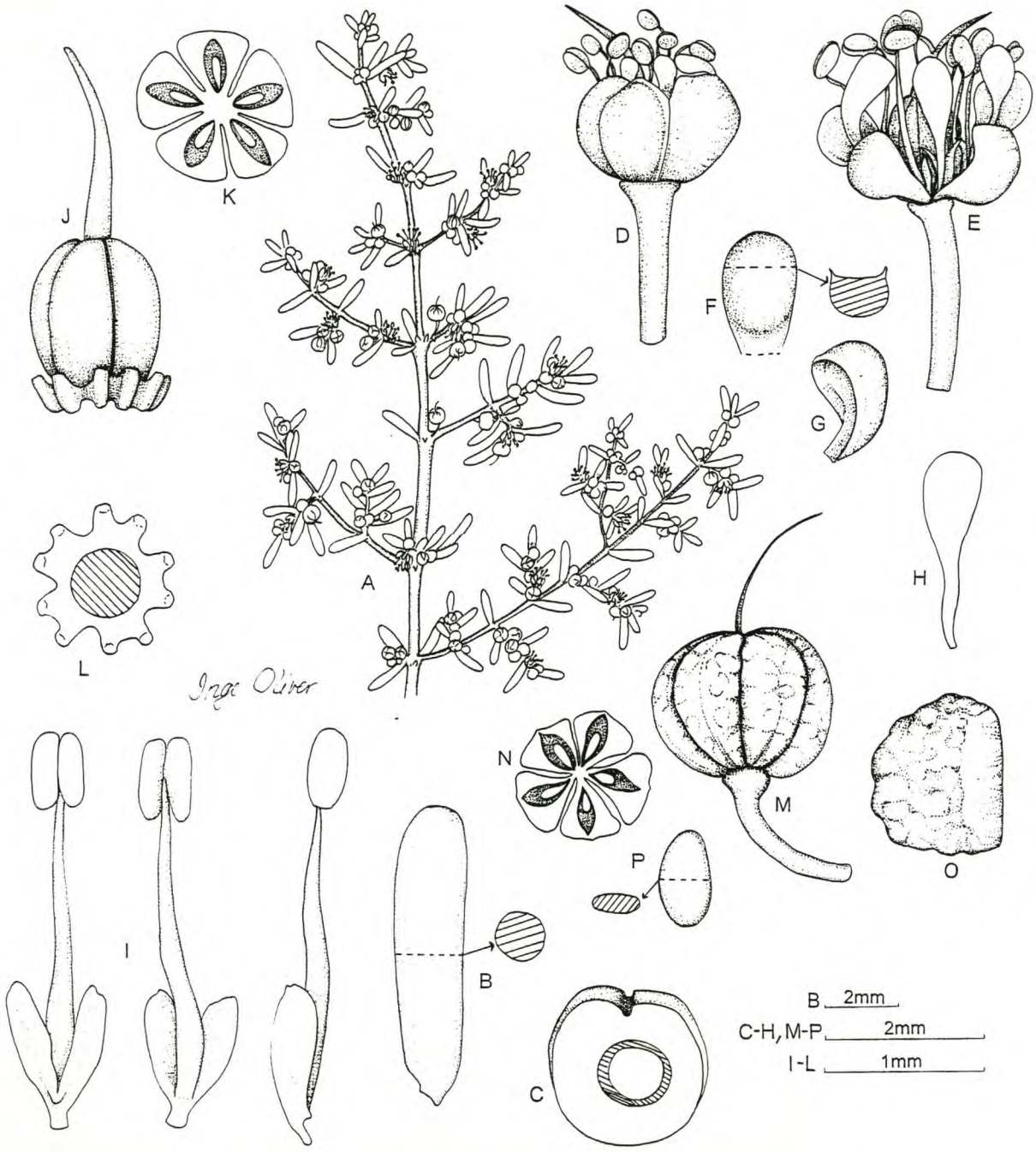


Figure 7.2.1. *Z. spongiosum, Van Zyl 3785.* A, flowering branch, life-size; B, leaf with section; C, section of internode; D, side-view of flower bud; E, side-view of open flower; F, dorsal view of sepal, and section of sepal; G, side-view of sepal; H, petal; I, ventral-view, dorsal-view and side-view of staminal scale; J, ovary with prominently lobed nectar disc; K, section of ovary; L, top-view of nectar disc; M, side-view of mature fruit; O, side-view of a mericarp; P, seed with section of seed.

prominently spongy outer walls (Figure 3.12. M, N) . The fruits of *Z. inflatum* are broadly obovoid, and have inflated mericarps with thin, smooth, glossy walls. The fruit shape of *Z. simplex* varies from narrowly to broadly obovate, obcordate or rotundate and the mericarps have thin, nearly transparent lateral walls always with several rows of dark tubercles along its outer margins (Figure 3.12. E—H). *Z. spongiosum* and *Z. simplex* have prostrate or somewhat decumbent habits reaching heights of at most 0.1 m and diameters of 1.0 m, whereas *Z. inflatum* grows upright and is taller, reaching a height of 0.3 m and a diameter of 0.5 m. Table 7.1 summarizes the characters of the species in § *Annua*.

Distribution and ecology

Z. spongiosum occurs in a wide belt along the north-western coastline of Namibia, extending into Angola. It is found from the Kunene basin in the north to as far south as Gobabeb near the Kuiseb River. Inland it is found as far east as the Etosha pan and Gross Barmen, near Okahandja (Figure 7.2.2). Along the coast it occurs in vegetation classified as **Desert Biome**, further inland in the **Nama Karoo Biome** and on the eastern side of its distribution in **Savanna Biome** (Irish 1994). These three Biomes receive a low precipitation during summer which is supplemented with regular coastal fogs in the Desert Biome. Winters are cold and dry.
Populations are large, consisting of many individuals or can consist of occasional, scattered individuals over large areas. *Z. spongiosum* occurs on sandy or calcareous, stony substrates often close to rivers or water courses or around pan edges or on flood plains. Flowers and fruits are found throughout the year. Flowers are sweet-scented and visited by ants as well as bees. Notes on herbarium sheets mention utilization by baboons, but nothing about grazing by herbivores.
Because of the large size of some populations and the widespread distribution, this species seems not threatened at present.

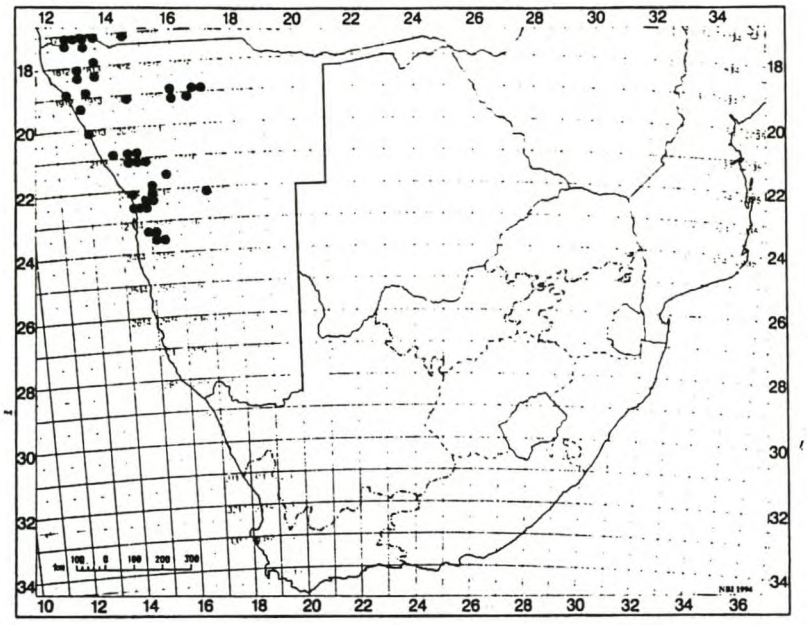


Figure 7.2.2. Geographical distribution of *Z. spongiosum*.

Specimens examined

–1213 (????); Benguella, waste ground (–DB), *Pocock 864* (BOL).

–1712 (Posto Velho): In mountain valley above Marien Flache (–AD), *Kotze 117* (WIND); Kunene flood plain at Otjomborombonga (–BA), *Leistner et al. 119* (PRE); Plateau on Baynes Mountains (–BB), *Goyns 3* (PRE).

–1713 (Swartbooisdrif): Camp area, 10 M S of Epupa (–AA), *Merxmüller & Giess 30553* (PRE, WIND); On limestone flats 4 km W of Epupa Falls (–AB), *Giess & Wiss 3240* (WIND); Sandy, stony places at Otjijangasema (–AC), *Rycroft 2474* (NBG); Silty soil near watercouse, 30 M NW of Ohopoho (–CD), *Davies, Thompson & Miller 30* (PRE, WIND); Otjivero, 30 M W of Ohopoho (–CD), *Gibson 104* (WIND).

–1714 (Ruacana Falls): Great Falls on Kunene River (–AB), *Barnard 662* (SAM).

–1812 (Sanitatas): Red, sandy soil 10 M E of Sanitatas (–BB/BD), *Story 5686* (PRE); At Okonjambo, 80 M W of Ohopoho on tributary of of Hoarusib river (–BD), *Griffin 157* (WIND); Sarusas on Kumib river (–CD), *Rycroft 2479* (NBG); Gravel and sand on Namib plane near Sarusas (–CD), *Kers 1466* (WIND).

–1813 (Ohopoho): Limestone flats at Otjihu (–AD), *De Winter & Leistner 5664* (PRE); Gomatum valley, 33 km SE of Purros (–CC), *Edwards 4475* (WIND).

–1815 (Okahakana): Deep, powdery sand in Okondeka area (–DD), *Le Roux 1538* (WIND).

–1816 (Namutoni): Okerfontein (–DC), *Schmidt 307* (PRE, WIND); Okevi, Etosha National Park (–DD), *Le Roux 1697* (WIND); Calcareous gravel near Namutoni Fort (–DD), *De Winter 2980* (PRE); *Barnard s.n.* (SAM 26628); Namutoni (–DD), *Walter 373* (WIND).

–1912 (Hoanib Mouth): Floodplain, Hoanib river, 5 km E of dunes (–BD), *Cooper 24* (WIND).

–1914 (Kamanjab): Hard ground near watercourse at Khoabendus, Otjovasandu (–AD), *Story 5657* (PRE).

–1915 (Okaukuejo): In Okaukuejo Camp (–BB), *Troughton 110* (GRA); *Tinley 1100* (PRE); *Jordaan s.n.* (STE 31746 in NBG).

–1916 (Gobaub): Rietfontein, Etosha Pan (–AB), *Maguire 1536* (NBG, PRE); *Van Zyl 4492* (NBG, PRE, S, WIND).

–2013 (Unjab Mouth): 9 M N of Torrabaai (–AA), *December 387/789* (WIND); Mountains 23 km SE of Torrabaai (–AD), *Giess 8032* (WIND).

–2014 (Welwitchia): Between Probeer and Droëhoek on road to Doros (–CD), *Craven 179* (WIND); On river bank at confluence of Goantagab and Uchab rivers (–DC), *Craven 2393* (WIND); Flats on Mispah: OU 524 (–DC), *Giess 7903* (WIND);

–2114 (Uis): In sandy soil, Numasschlucht, Brandberg (–AB), *Muller & Giess 359* (WIND); 30 km W of Brandberg (–AB), *Taylor 3422* (NBG); Sandy rivers, Tsisabschlucht, Brandberg (–BA), *Strey 2403* (PRE); 15 M from Brandberg (–BB), *Liebenberg 4975* (WIND).

–2115 (Karibib): Klein Spitzkop (–CC), *Jensen s.n.* (WIND 16197); Spitzkoppe W of Erongo Mountains (–DA), *Watmough 891* (PRE).

–2214 (Swakopmund): Sandy river bed of Omaruru at the throughfare to Hentiesbaai (–AB), *Giess 7841* (WIND); S of Aranos on B2 (–BD), *Van Zyl 3787* (NBG); Sandy river bed N of Swakop river (–CB), *Research Station Gobabeb 90* (WIND); Sandy river bed at Swakopmund (–DA), *Bradfield 473* (PRE); *Pearson 527* (SAM); *Ihlenfeldt 1945* (PRE); On dolerite koppie at Goanikontes oasis (–DB), *Brink 575* (GRA); Track between Goanikontes and Rössing mountain (–DB), *Kers 1293* (WIND).

–2215 (Trekkopje): Sukses 90 on Usakos-Swakopmund road (–AA), *Kers 2693* (WIND); Around salty pool, Panner, Rössing mine (–AC), *Craven 1572* (WIND).

–2216 (Otjimbingwe): Entrance to Gross Barmen (–BB), *Van Zyl 3785* (NBG, WIND).

–2314 (Sandwich Harbour): In Kuiseb river, ± 10 M from Gobabeb towards Swartzrand and Rooibank (–BD), *Kers 282* (WIND).

–2315 (Rostock): In Kuiseb river at Gobabeb (–AC), *Van Wyk 442* (PRE); Granitspalten at Gobabeb (–CA), *Giess 7834* (WIND); *Koch s.n.* (PRE 45793); *Theron 3728* (WIND); Kuiseb river at Hope mine (–CA), *Kers 1593* (WIND); Between swimming pool and laboratory at Gobabeb (–CA), *Grobbelaar 2524* (PRE); Plain near Zebra pan (–CB), *Jensen 204/1530* (PRE, WIND).

Unknown or no precise localities: Kunene river, *Hall 468* (NBG); Etosha National Park, *Le Roux 359* (PRE, WIND).

7.3 Zygophyllum inflatum *Van Zyl*, sp. nov. (§ *Annua*), *Z. simplicis* et *Z. spongiosi* affinis propter habitum mollem annuum vel biennem [foliaque simplicia], sed mericarpiis laevibus nitidis inflatis, parietibus tenuibus; mericarpia *Z. simplicis* parietibus laevibus paene translucidis seriebus tuberculorum obscurorum secus marginem exteriorem; mericarpia *Z. spongiosi* parietibus exterioribus crassis spongiosisque. TYPE - Angola: National Park Jona in Mocamedes Province, *Ward & Ward 27* (WIND, holo).

Erect, herbaceous, succulent annual or biennial, branched from base, reaching a height of 0.3 m and a diameter of 0.5 m. *Stems:* old stems usually nude with slightly swollen nodes, yellow or cream, smooth but when dry usually displaying numerous embedded crystals giving it a warty surface; young stems green or yellow, leafy, with a prominent ventral groove. *Leaves*: oldest leaves opposite, younger leaves opposite a branch, alternating on stems, sessile, broadly obovoid, succulent, apex obtuse, base narrowed, 7–14 x 3–4 mm; stipules triangular, membranous, margins sometimes lacerated, two each on ventral and dorsal sides, 1 x 0.5–1 mm, semi-permanent. *Flowers* solitary or 2 together, axillary. *Pedicel* 1 mm long. *Sepals* 5, ovate or obovate, membranous margined, outer ones with a succulent, cucullate apex, 2–3 x 1–1.5 mm. *Petals* 5, spathulate, apex round, base with long claw, yellow, 4.5 x 1.5 mm. *Nectar disc* fleshy, smooth, prominently 10 lobed, lobes arranged into 5 pairs, each pair orientated outwards and upwards. *Stamens* 10, in two whorls; filaments terete, 4 mm long; staminal scales 10, alternately differently orientated, bipartite almost to the base, each segment ovate, obovate or oblong, apex truncate or rounded or obliquely lobed, side margins entire, base narrowed, 1.8 x 0.6 mm, ± 1/3 the length of the filament. *Ovary* oblong, 5-parted, each part indented; style terete; stigma capitate. *Fruit* a 5-parted, septicidal schizocarp, broadly obovoid, 4 x 4 mm, breaking up in 5 inflated mericarps, each with a ventral opening and thin, smooth and glossy exocarp without any tubercles or ridges, also able to split open along an inner (endocarp) dorsal suture. *Seed* pyriform, brown, 2—4 per mericarp, 0.8 x 0.5 mm, when immature attached by a long funicle, testa granular, farinous, producing structureless, jelly-like mucilage when placed in water.

Diagnostic features and affinities

Z. inflatum is distinguished by its broadly obovoid fruit, 4 x 4 mm in size, consisting of 5 inflated mericarps (hence the Latin epithet which refers to the bladder-like mericarps). Its inflated mericarps have thin, glossy walls and lack the dark tubercles found on the mericarps of *Z. simplex* or the many layers of spongy cells found on the mericarps of *Z. spongiosum*. *Z. inflatum* is also distinguished by its erect habit reaching a height of 0.3 m and a diameter of 0.5 m whereas *Z. simplex* and *Z. spongiosum* have a prostrate or decumbent habit only reaching heights of 0.1 m and diameters of 1.0 m.

Z. inflatum and its allies, *Z. simplex* and *Z. spongiosum*, are herbaceous annuals or at most biennials with succulent, obovoid, simple leaves. They display a simpodial way of branching with the oldest leaves opposite and the younger leaves opposite a branch. The leaves have a single layer of palisade cells under the leaf epidermis. This layer causes a distinct reticulated pattern on the surface of dried leaves. Table 7.1 summarizes the characters of the species in § *Annua*.

Distribution and ecology

Z. inflatum is confined to the lower Kunene River basin (Figure 7.3). Only three collections were studied. No living plants were seen. In Kaokoland, Namibia, on the southern side of the Kunene River, *Z. inflatum* is described as common and occurring on arid plains and sandy pediments. The vegetation along the coast is classified as **Desert Biome** and further inland as **Nama Karoo Biome** (Irish 1994). Both these Biomes receive a low, annual precipitation primarily during summer. In the Desert Biome regular coastal fogs are probably also utilized, contributing to the water regime necessary for survival. In Mocamedes Province, Angola, *Z. inflatum* occurs in sand amongst rocks at five meters above sea level. Flowers and fruits are found during July, September as well as in January. All specimens studied had an abundance of fruits, most of which contained a few seeds. Not enough data about this species is available to express any opinion about its conservation status.

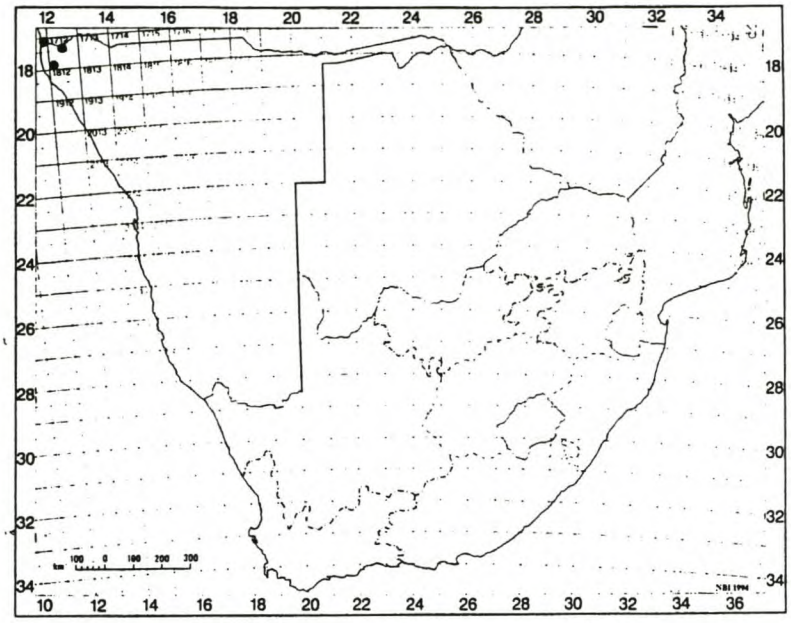


Figure 7.3.1. Geographical distribution of *Z. inflatum*.

Specimens examined

–1711: National Park Jona in Mocamedes Province (–BB), *Ward & Ward 27* (WIND).

–1712 (Posto Velho): 7.5 km S of Otjinungua in Kaokoland (–AD), *Giess 10530* (PRE, WIND); 60 km S of the Kunene River and 40 km inland (–CC), *Robinson R & K 92* (GRA).

§ *Prismatica* Van Zyl, sect. nov. Caules juvenes alati; folia simplicia, sessilia, opposita; inflorescentia cyma scorpioidea; discus nectareus 10-lobatus, lobi in paris 5 dispositi, quodque par cum area centrali parum elevata areaque depressa inter paribus; filamenta quam squamae 5plo longiora; fructus viventes succulenti, oblongi, fructus sicci 5-partiti vel 5-angulati, prismatici.

Type species: *Z. prismatocarpum* Sond.

Diagnostic features

Young stems winged

Leaves simple, sessile

Inflorescence a scorpioid cyme

Nectar disc smooth, 10-lobed, lobes arranged in 5 pairs, each pair with a slightly raised central area and a sunken area between pairs, the disc as a whole slopes slightly towards its periphery.

Staminal scales biparted to near the base

Filament to scale ratio 5 : 1

Fresh fruits succulent, oblong, dry fruits 5-parted or 5-angled, prismatic

Van Huyssteen (1937), included *Z. prismatocarpum* in her original publication of the § *Bipartita,* although it was the only species with sessile, simple leaves amongst species with petiolate, bifoliolate leaves. With regard to its simple, sessile leaves and winged stems, *Z. prismatocarpum* is now removed from § *Bipartita* and placed in a section of its own, § *Prismatica* Van Zyl. This treatment correlates with the subdivisions of subgenus *Zygophyllum* where species with simple leaves are placed together in § *Paradoxa* Huysst. The new § *Prismatica* comprises three species, *Z. prismatocarpum*, *Z. pterocaule* and *Z. patenticaule*. Table 7.2 summarizes the characters of the species in § *Prismatica.*

Key to species in § *Prismatica*:

1a Decumbent shrublet reaching a height of 0.15 m, stems with two, prominent wings in a dorso-ventral plane.....*Z. pterocaule*

1b Erect or spreading shrubs reaching heights of more than 0.3 m, stems with a single wing.....2

2a Erect, virgate shrubs, reaching a height of 1.5 m, with a single, narrow wing present on young stems, inflorescence a dense, scorpioid cyme..... *Z. prismatocarpum*

2b Shrublet with spreading stems, reaching a height of 0.4 m, with a single, narrow, ventral wing present on young stems, inflorescence an elongated, well spaced, scorpioid cyme ..... *Z. patenticaule*

Table 7.2. Characters of the species in § *Prismatica*

Z. PRISMATOCARPUM	Z. PATENTICAULE	Z. PTEROCAULE
erect, virgate shrub, 1.0 m or more in height	spreading shrub, reaching 0.4 m in height	decumbent shrublet, reaching 0.15 m in height
young stems with a ventral wing	young stems with a ventral wing	young stems with a ventral and a dorsal wing
inflorescence a dense, contracted scorpioid cyme	inflorescence an elongated, well spaced scorpioid cyme	inflorescence a short scorpioid cyme
leaves suborbicular / obovate, often with cuneate base, 16–30 x 14–18 mm	leaves suborbicular or widely obovate, rarely cuneate based, 15–17 x 13–18 mm	leaves suborbicular, never with cuneate base, 20–30 x 20–30 mm
petals spathulate, 4.5–5.5 x 1.0–2.0 mm	petals spathulate, 4.5–5.0 x 2.0–2.5 mm	petals spathulate, 7.0–9.5 x 2.5–3.0 mm
filaments 5—7 mm long	filament 4.5—5.5 mm long	filaments 6—7 mm long
filament / scale ratio 5 : 1	filament / scale ratio 5 : 1	filament / scale ratio 5 : 1
nectar disc type 3	nectar disc type 3	nectar disc type 3
fresh fruit succulent, obovoid or oblong, 5-lobed	fresh fruit succulent , obovoid or oblong, 5-lobed	fresh fruit succulent, obovoid or oblong, 5-lobed

7.4 Zygophyllum prismatocarpum *Sond.* in Flora Capensis 1 :357 (1860); Huysst.: 60 (1937); A.Schreib: 94 (1963); A.Schreib. in Merxm.: 65 (1966). TYPE - Northern Cape: Between Kaus, Natvoet and Doornpoort , *Drège s.n.* (S!, lecto., designated here, P!, TCD!).

Zygophyllum prismaticum E. Meyer in Drège: 93 (1843). *Drège s.n.*, (KIEL!), nom nud.

Zygophyllum altum *Dinter 6383* (BOL, PRE, S), nom. nud.

Erect, virgate shrub, sparsely branched from the base, reaching a height of 1.5 m and a diameter of 0.8 m. *Stems*: old stems woody, gray or dark gray; younger branches gray, smooth, round in cross section, with a ventral wing. *Leaves* opposite, sessile, simple, glaucous; lamina articulate, suborbicular or widely obovate, succulent, leathery in texture, apex rounded, base obtuse, often cuneate, gradually reduced in size and with longer cuneate bases towards branch apex, 16–30 x 14–18 mm; stipules filamentous, minute, caducous, two on ventral and two on dorsal side of stems. *Flowers* arranged in a dense, erect, scorpioid cyme. *Pedicel* 3—5 mm long, elongating in fruit. *Sepals* 5, suborbicular or obovate, articulate, some membranous margined, outer three succulent, cucullate, 3–4 x 2–3 mm. *Petals* 5, spathulate, with a long claw, white, 4,5–5,5 x 1.0–2.0 mm. *Nectar disc* fleshy, smooth, 10-lobed, lobes arranged in 5 pairs and orientated downward, each pair with a slightly raised central area and with a sunken area between pairs, the disc as a whole slopes slightly towards its periphery. *Stamens* 10, in two whorls; filaments terete, 5—7 mm long; staminal scales biparted almost to the base, alternately differently orientated, the antipetalous scales clasping a lobe of the ovary, the antisepalous scales fitting in between two lobes of the ovary, segments of scale oblong, apex obliquely lobed, margins entire, base narrowed, 1.0 x 0.8 mm, ± 1/5 the length of the filament. *Ovary* narrowly obovoid or ellipsoid, 5-parted, sometimes globulate on upper half; style terete, stigma simple. *Fruit* an erect or drooping, septicidal schizocarp; when fresh, obovoid or oblong, 5-lobed, succulent, juicy; when dry, prismatic and prominently 5-parted, 9–11 x 4–5 mm, breaking up in 5 mericarps. *Seed* pyriform, brown, 10—12 per locule, 1.5 x 1.0 mm, when immature attached by a

long funicle, testa grainy, nearly transparent when wet, producing structured mucilage with short, spiral inclusions that seem to unravel at apex (Figure 7.4.1).

Diagnostic characters and affinities

Z. prismatocarpum is distinguished by its simple, succulent, suborbicular or obovate leaves, by its young stems with a single ventral wing and by its erect, virgate stems of 1.0 m or more (Figure 7.4.2.A) ending in a compact scorpioid cyme bearing many prismatic fruits (Figure 7.4.1). The specific epithet refers to its prismatic fruits. It is allied to *Z. pterocaule* and *Z. patenticaule* with regard to leaf and floral morphology, but differs from them in habit and inflorescence. *Z. pterocaule* is a decumbent shrub (Figure 7.4.2.C), bearing its flowers in a short or small scorpioid cyme (Figure 7.6.1.A). *Z. patenticaule* has spreading branches reaching a height of 0.4 m (Figure 7.4.2.B), bearing regularly spaced flowers arranged in elongated scorpioid cymes (Figure 7.5.1.A). These three species have similar sub-orbicular to broadly obovate leaves. However, the leaves of *Z. prismatocarpum* often have a cuneate base whereas the leaf bases of *Z. pterocaule* and *Z. patenticaule* are usually obtuse. With regard to texture, the leaves of *Z. prismatocarpum* resemble those of *Z. pterocaule*, both displaying succulent leaves which become leathery when dry and which exhibit many prominent, embedded crystals. The leaves of *Z. patenticaule* are thin and smooth, in the dry state displaying a few, small crystals. Characters of these three species are summarized in Table 7.2.

Distribution and habitat

Z. prismatocarpum is widespread along the west coast of southern Namibia and the Northern Cape (Figure 7.4.3). The Luderitz area forms its northern boundary and it occurs as far south as Kleinsee and Steinkopf. In Namibia it occurs in vegetation classified as **Desert Biome** and **Succulent Karoo Biome** (Irish 1994). In the Northern Cape it occurs in **Succulent Karoo Biome**: Lowland and Upland Succulent Karoo (Hoffman 1996). The Succulent Karoo Biome receives rains during winter months with extreme summer aridity. The Desert Biome receives

Figure 7.4.1. *Z. prismatocarpum*. A, habit, *Van Zyl 3899*; B, leaves, flowers and immature fruit, *Van Zyl 3899*; C, mature fruit, *Van Zyl 4474*.

A

B

C

Figure 7.4.2. Habits of species in § *Prismatica*. A, *Z. prismatocarpum, Van Zyl 3899*, erect, virgate shrub; B, *Z. patenticaule, Van Zyl 3914*, shrublet with spreading branches; C, *Z. pterocaule, Van Zyl 4064*, decumbent shrublet.

primarily summer rains of very low quantities, but the regular occurrence of coastal fog plays an important role in supplementing the water needs of mainly *Arthraerua* and *Zygophyllum* species (Irish 1994). Populations are usually large and include seedlings and juveniles. Plants of *Z. prismatocarpum* are conspicuous because of their height. Collectors labels mention a variety of substrates like granite, sand, red sand, quartz, limestone, shale and gypsum. Grazing damage rarely occurs and this species seems to be unpalatable. The flowering period is from July to October with a peak in spring and fruits are found over a longer period of time. Because of the many and usually large populations as well as the large distribution area, this species seems not to be threatened at present. Amongst the people in the Richtersveld this species is known as Penbos and is used as firewood.

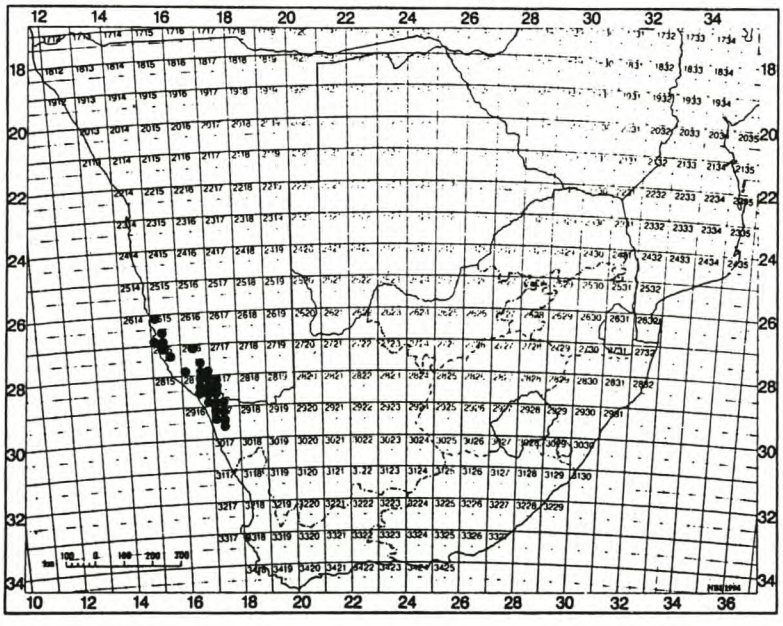


Figure 7.4.3. Geographical distribution of *Z. prismatocarpum.*

Specimens examined

–2615 (Luderitz): Sturmhausberge, dry water course (–AA), *Hardy & Venter 4429* (PRE); Kovis mountains E of Luderitz (–CB), *De Winter & Hardy 7914* (WIND); Haalenberg E of Luderitz (–CB), *Merxmüller & Giess 3115* (PRE), *Pillans BOL 27376* (BOL); S of Luderitz (–CC/CD), *Botha 3268* (PRE); Near Grillenthal S of Luderitz (–CD), *Van Zyl 3874* (NBG).

–2715 (Bogenfels): 23 km S of Grillental (–AB), *Merxmüller & Giess 28374* (PRE, WIND); Rheinpfalz (–AB), *Dinter 6383* (BOL, PRE); Klinghardtberge, Spitzkuppe Sud, (-BC), *Watmough 858* (PRE); Base of Klinghardt mountain (–BC), *Muller 700* (WIND); *Whitehead WIND 16077* (WIND).

–2716 (Witputz): Arutal 25, 40 km S of Aus (–AB), *Van Zyl 3888* (NBG); Namuskluft 88, Luderitz district (–CC), *Jancowitz 165* (WIND); Nord Witputz 22, N of Rosh Pinah (–DA), *Van Zyl 3895* (NBG, WIND); At Police Station, Witputz (–DA), *Giess, Volk & Bleissner 5335a* (WIND); Spitskop farm, on wind blown sand and calcrete (–DC), *Van Berkel 541/W15* (NBG, WIND); *Giess 14394* (WIND); V*an Zyl 3899* (NBG, WIND); Lorelei valley, along Orange river (–DD), *Jancowitz 280* (WIND); On granites, Namuskluft, district Luderitz (–DD), *Mittendorf 12* (PRE, WIND), *Logan 398* (WIND), *Giess, Volk & Bleissner 5365* (WIND).

–2816 (Oranjemund): Schakalsberge, district Luderitz Sud (–BA*), Merxmüller & Giess 2303* (PRE, WIND); 18 km S of Rosh Pinah (–BB), *Goldblatt 7023* (NBG, PRE); 6 km N of Rosh Pinah (BB), *Craven 1226* (WIND); Dry river beds opposite Sendelingsdrift (–BB), *Pearson 6107* (BOL); S of Rosh Pinah (–BB), *Van Zyl 3912* (NBG, WIND); Jakkalsberg, Rooi Lepel, LUS (–BC), *De Winter & Giess 6167* (WIND); Between Bloeddrif and Anniskop, Orange river course (–BD), *Van Zyl 4067* (NBG); Helskloof, Richtersveld (–BD), *Glen 755* (BOL); Bottom part of Helskloof, Richtersveld (–BD), *Grobbelaar 2519* (PRE); Numees, Richtersveld (–BD), *Jurgens 78.3* (PRE); *Jurgens 9161* (NBG); *Jurgens 10200* (NBG); *McDonald 699* (NBG); *Van Jaarsveld 1468* (NBG); 5 km from Annisfontein on way to Ochta (–DA), *Botha 3216* (PRE); S of Khubus, Richtersveld (–DB), *Le Roux 2861* (NBG); Dry river bed, Holgat (–DD), *Wisura 3036* (NBG).

–2817 (Vioolsdrif): Between the confluene of Boom and Dabimub rivers with the Orange river (–AA), *Van Zyl 4474* (PRE, NBG, WIND); SW of Kodaspiek, Richtersveld (–AA), *Thompson & Le Roux 269* (NBG); Upper reaches of Gannakoeraprivier opposite Oomsberg (–AC), *Van Jaarsveld & Kritzinger 6295* (NBG); Lower slopes on N side of Rosyntjiesberg, Richtersveld (–AC), *Oliver, Tölken & Venter 283* (NBG); N slopes of Wildeperderant, Eksteensfontein (–CA), *Van Zyl 4053* (NBG); Dolomite Peaks, Richtersveld (–CA), *Munro PRE 45829* (PRE); Black Hills, Holgat river, Richtersveld (–CA), *Schultze 709x* (BOL, NBG); Sperlingsputs (–CA), *Jankowitz 259* (WIND); Narrow kloof at Skouerfontein, Richtersveld (–CA), *Van Zyl 4058* (NBG); Gravel road W of Wildeperderand, Richtersveld (–CC), *Van Zyl 4572* (BOL, NBG, WIND); W of Spitskloof, Lekkersing, Richersveld (–CC), *Van Zyl 4049* (NBG); Uitspanspoort, N of Lekkersing (–CC), *Van Zyl 4573* (B, BOL, NBG, S, WIND); N of Kliphoogte, Eksteensfontein, Richtersveld (–CD), *Van Zyl 4041* (NBG).

–2917 (Springbok): The Poort, 9 km S of Lekkersing (–AA), *Thompson & Le Roux 61* (NBG, PRE); Between Springbok and Kleinzee (–AB), *Le Roux 2818* (NBG); Between Boesmanpunt and Sabieboomrante, S Richtersveld (–AB), *Van Zyl 4037* (NBG, PRE, WIND); 10 km from Port Nolloth, going towards Steinkopf (–AC), *Van Zyl 4081* (NBG); 2 M NW of Vaalheuwel, Namakwaland (–AD), *Acocks 19415* (WIND); 47 km from Steinkopf going towards Port Nolloth (–AD), *Basson 41* (PRE); Noupoortsberg, E of Kleinsee (–CB), *Van Zyl 4084* (NBG); First river valley after turn off to Soebatsfontein on Springbok to Kleinsee road (–CB), *Boucher 3134* (NBG).

7.5 Zygophyllum patenticaule *Van Zyl*, sp. nov. (§ *Prismatica*). TYPE - Namibia: Between the confluence of Boom and Dabimub Rivers with the Orange River (–AA), *Van Zyl 4471* (NBG, holo., PRE, S).

Zygophyllum prismatocarpum *Sond.* var. ß **diffusum** *Sond.*: 357 (1860): A.Schreib. 94 (1963). TYPE - Northern Cape: Between Natvoet and Gariep, 1000—1500 feet, Drège s.n. (S, lecto!, designated here, K!, P!, TCD!)
Zygophyllum prismaticum *E.Mey. in Drège* var. ß *diffus*: 92 (1843). nom nud.
non Chiov.: 111 (1929).

Z. prismatocarpum Sond. var ß *diffusum* Sond. is herewith instated as a species distinct from *Z. prismatocarpum* Sond. Already E. Meyer had this feeling, on the lable of a Drège s.n. (S) he wrote: " an spec. pecul.?

Spreading shrublet, branched from woody base, reaching a height of 0.4 m and a diameter of 0.8 m, sometimes forming low hummocks in areas with moving sand particles. *Stems*: old stems woody, dark gray, widely spreading; younger branches gray, smooth, with a single, ventral wing. *Leaves* opposite, sessile, simple, glaucous; lamina articulate, suborbicular or widely obovate, oldest leaves sometimes slightly succulent, younger leaves membranous, 15–17 x 13–18 mm, gradually reducing in size towards branch apex, apex rounded, base rounded or rarely cuneate; stipules filamentous, minute, two on ventral and two on dorsal side of stem, caducous. *Flowers* solitary or rarely two together, arranged in an elongated scorpioid cyme bearing regularly spaced, nodding buds, erect flowers and later drooping fruits. *Pedicel* 3—8 mm long. *Sepals* 5, suborbicular or obovate, articulate, some cucullate, with membranous margins, outer three succulent, 3–4 x 2–3 mm. *Petals* 5, white, spathulate, apex rounded, base with a long claw, 4.5–5.0 x 2.0–2.5 mm. *Nectar disc* fleshy, smooth, 10-lobed, lobes arranged in 5 pairs and orientated downwards, each pair with a slightly raised central area and with a sunken area between pairs, the disc as a whole slopes slightly towards its periphery. *Stamens* 10, in two whorls; filaments terete, 4.5—5.5 mm long; staminal scales 10, bipartite almost to the base, alternately differently orientated, the antipetalous scale clasping a lobe of the ovary, the antisepalous scale fitting in between two lobes of

the ovary, segments ovate, margins entire, 0.8–1.0 x 0.4–0.5 mm, ± 1/5 as long as the filament. *Ovary* narrowly ellipsoid, 5-parted; style terete; stigma simple. *Fruit* a drooping, septicidal schizocarp: when fresh, succulent, oblong, 5-lobed; when dry, prismatic, prominently 5-parted, 8–10 x 3–4 mm, breaking up in five mericarps. *Seed* pyriform, brown, 8—10 per locule, 2 x 1 mm, when immature attached by a long funicle, testa grainy, nearly transparent when wet, producing structured mucilage with short spiral inclusions that seem to unravel at the apex (Figure 7.5.1).

Diagnostic characters and affinities

Z. patenticaule is recognized by its simple, sessile, sub-orbicular or broadly obovate leaves, by the single, ventral wing on its young stems and by its prismatic fruits. It is allied to *Z. prismatocarpum* and *Z. pterocaule* in leaf and fruit morphology, but can be distinguished from them by its different inflorescence and habit. *Z. patenticaule* has widely spreading branches (hence the specific epithet) radiating from a woody base, reaching a height of 0.4 m. Its flowers are arranged in an elongated scorpioid cyme with flowers regularly spaced, single or two together. *Z. prismatocarpum* has virgate branches reaching a height of 1 m or more, also with a single, ventral wing on young stems. Its flowers are arranged in a dense, contracted, scorpioid cyme. *Z. pterocaule* is a decumbent shrublet with nearly horizontal branches and with two prominent wings on its younger stems and its flowers are arranged in a short scorpioid cyme. Characters of these three species, are summarized in Table 7.2.

Distribution and habitat

Z. patenticaule is limited to the lower Orange River basin (Figure 7.5.2). In Namibia it occurs in the Rosh Pinah area and further east towards Ai-Ais in vegetation classified as **Succulent Karoo Biome** characterized by chamaephytic dominance (Irish 1994). In the Northern Cape it occurs south of Alexander Bay in the Swartbank area, and in the Richtersveld. It is found below the escarpment on rich soils derived from granite and gneiss in vegetation classified as **Succulent Karoo Biome**: Lowland Succulent Karoo (Hoffman 1996). This represents an extremely arid vegetation type dominated by dwarf shrubs, belonging to the *Mesembryanthemaceae.* Both these biomes receive a low annual rainfall during winter with summers hot and dry. Populations are large and consist of hundreds of

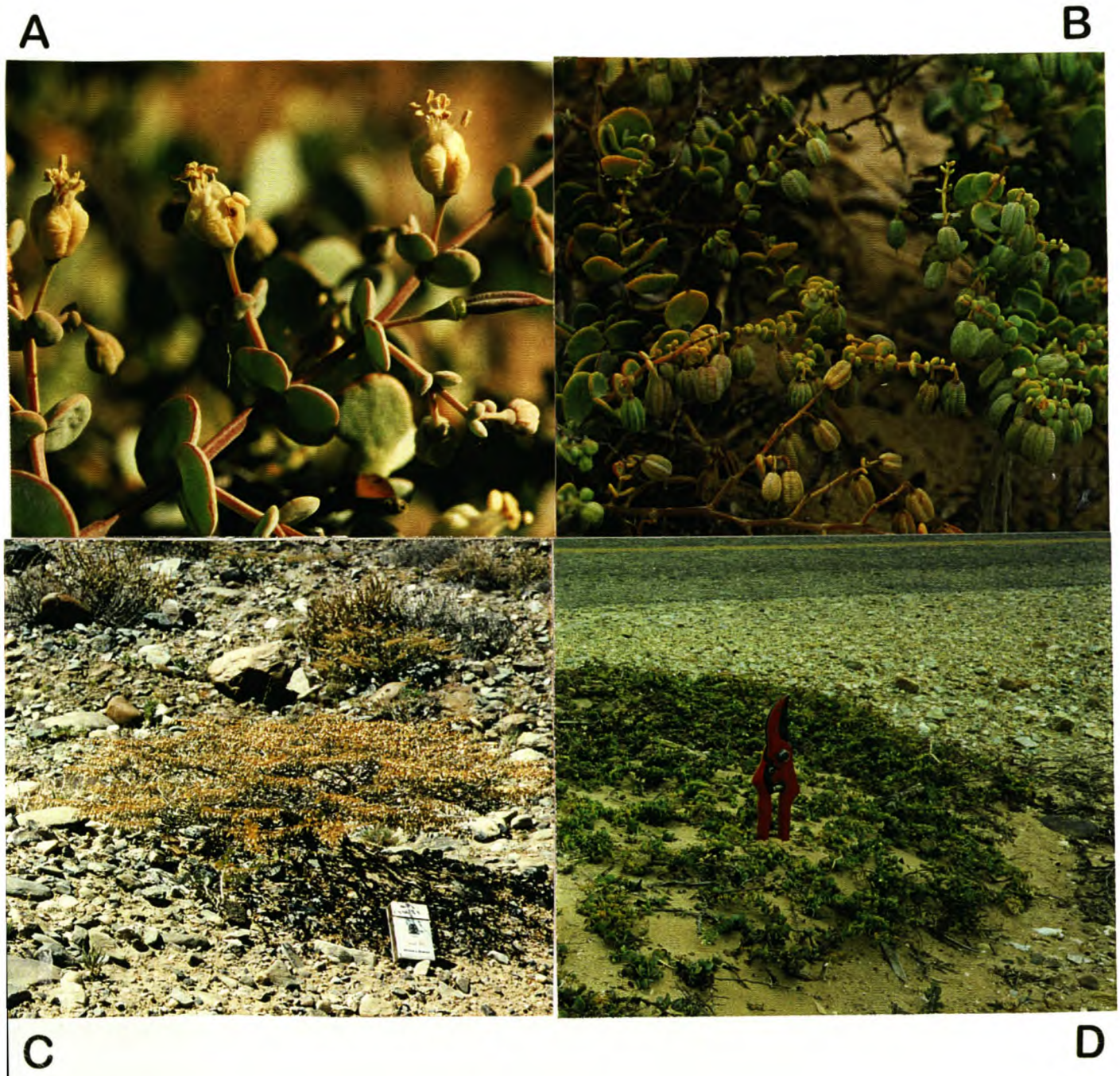


Figure 7.5.1. *Z. patenticaule*. A, flowers, young fruits and leaves on part of an elongated, regularly spaced, scorpioid cyme, *Van Zyl 3914*; B, succulent, fresh fruits, *Van Zyl 4565*; C, fruiting shrublet with spreading branches, *Van Zyl 4471*; D, hummock forming habit near Alexander Bay, *Van Zyl 4566*.

individuals, always growing in association with other *Zygophyllum* species, especially *Z. prismatocarpum*. These two species often grow close together but usually not intermixed, e.g. *Z. patenticaule* at the foot of a hill or ridge and *Z. prismatocarpum* slightly higher up. The flowering period is from August to September and fruits are shed several months after. Near Alexander Bay, on the shoulders of the tar road, flowering and fruiting specimens were collected later than normal, in December. These plants probably utilized the fog precipitation running from the edges of the tar road whereas a few meters away from the tar road, individuals were sterile and dry. No grazing damage occurs and it seems that this species is not palatable. Because of the large size of populations and the absence of grazing pressure, this species is probably not threatened at present.

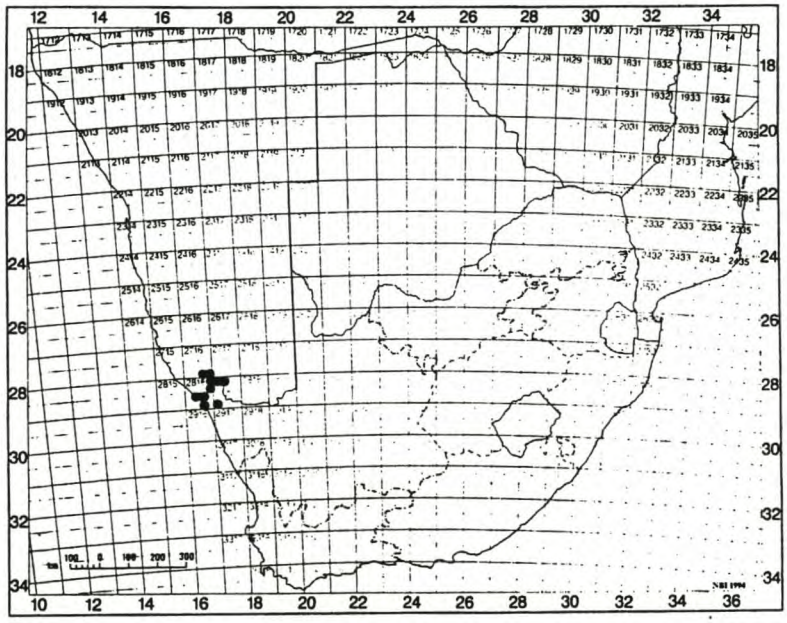


Figure 7.5.2. Geographical distribution of *Z. patenticaule*.

Specimens examined

–2715 (Bogenfels): Klinghardtberge, 100 km S of Luderitz (–BD), *Venter 8956* (BLOEMF).

–2716 (Witputz): SW mountain slopes on farm Spitskop, LU 111 (–DC), *Giess 14634* (PRE, WIND); E side of farm Namuskluft, LU 88 (–DD), *Giess, Volk & Bleissner 5368* (WIND).

–2816 (Oranjemund): River bed, 13 M N of Sendelingsdrift (–BB), *Merxmüller & Giess 3240* (WIND); Rocky ridge on Pokkiespramberg, Swartpoort (–BB), *Van Jaarsveld 1457* (NBG); Between Bloeddrift and Anniskop, (–BD), *Van Zyl 4069* (NBG); Numees, Richtersveld (–BD), *Jurgens 30* (PRE), *Jurgens*

10066 (NBG); Turn off to Helskloof, Richtersveld (–BD), *Van Zyl 3914* (NBG, WIND); Anniskop, NW of Khubus, Richtersveld (–BD), *Van Zyl 4141* (NBG); Between Alexander Bay and the turn off to Oranjemund (–CB), *Van Zyl 4566* (B, NBG, WIND); N of Alexander Bay, 4 km from turn off (–CB), *O'Callagan, Van Wyk & Morley 82* (NBG, PRE); Between Beesbank and Brandkaros, NE of Alexander Bay (–DA), *Van Zyl 4074* (NBG); ± 3 km S of Alexander Bay (–DA), *Van Zyl 4565* (NBG); Swartbank area, S of Alexander Bay (–DC), *Van Zyl 4078* (NBG);

–2817 (Vioolsdrif): Between the confluence of Boom and Dabimub rivers with the Orange River (–AA), *Van Zyl 4471* (NBG, PRE, S); Along the Noordoewer to Ai-Ais road (–AB), *Wiss 2107* (WIND); W of Wildeperderand, Richtersveld (–CC), *Van Zyl 4052* (NBG, PRE).

7.6 **Zygophyllum pterocaule** *Van Zyl* in Van Zyl & Marais, Bothalia 29,2 : 231 (1999). TYPE - Northern Cape: Cornellskop, W of Khubus, Richtersveld, *Van Zyl 4136* (NBG!, holo., B!, PRE!, S!, WIND!).

Decumbent, succulent, branched shrublet, up to 0.15 m high and 0.8 m in diameter. *Stems*: old stems woody, brown, with swollen nodes and rough bark; younger branches gray, smooth, with two prominent wings in a vertical plane. *Leaves* opposite, sessile, simple, glaucous; lamina articulate, suborbicular, succulent, 20–30 x 20–30 mm, gradually reduced in size towards branch apex; stipules filamentous, minute, caducous, two together on ventral and on dorsal side of stem. *Flowers* solitary or two together, arranged in a short, scorpioid cyme. *Pedicel* 4—9 mm long. *Sepals* 5, suborbicular or obovate, cuculate, articulate, some with membranous margins, outer 3 succulent, 4.0–5.5 x 2.0–3.5 mm. *Petals* 5, spathulate, margins sometimes undulate, long clawed, white, 7.0–9.5 x 2.5–3.0 mm. *Nectar disc* fleshy, smooth, 10-lobed, lobes arranged into 5 pairs, orientated downwards, each pair with a slightly raised central area and with a sunken area between pairs, the disc as a whole sloping slightly down towards its periphery. *Stamens* 10, in two whorls; filaments terete, 6—7 mm long; staminal scales biparted almost to the base, alternately differently orientated, the antipetalous scale clasping a lobe of the ovary, the antisepalous scale fitting in between two lobes of the ovary, segments of scale ovate or elliptic, apex acute or rounded, obliquely lobed, margins entire, 1.5 x 0.5 mm, ± 1/5 the length of the filament. *Ovary* narrowly ellipsoid, 5-parted, sometimes globulate; style terete; stigma simple. *Fruit* a drooping, septicidal schizocarp: when fresh, succulent, juicy, oblong, shallowly 5-lobed; when dry, 5-parted, prismatic, 9 x 6 mm, separating in five

mericarps. *Seed* pyriform, 8—10 per locule, 1.0 x 0.5 mm, light-brown, when immature attached by a long funicle, testa grainy, becoming nearly transparent when wet, producing structured mucilage with short, spiral inclusions that seem to unravel at the apex (Figure 7.6.1—2).

Diagnostic characters and affinities

Z. pterocaule is recognized by its simple, suborbicular, succulent leaves and by its young stems with two, prominent wings (hence the specific epithet which is Greek for winged stem). It is allied to *Z. prismatocarpum* and *Z. patenticaule* with regard to leaf and floral morphology, but differs from them in habit and in the number of wings on its stems. *Z. pterocaule* has a decumbent habit with nearly horizontal branches, reaching a height of only 0.15 m. *Z. prismatocarpum* is an erect shrub reaching a height of 1.0 m or more and *Z. patenticaule* has spreading branches, reaching a height of 0.4 m. The young stems of *Z. pterocaule* have two prominent wings in a vertical plane, those of *Z. prismatocarpum* and *Z. patenticaule* have only one, less prominent, wing each. Characters of these three species are summarized in Table 7.2.
When sterile *Z. pterocaule* could be confused with *Z. cordifolium* (§ *Paradoxa,* subgenus *Zygophyllum*), also with simple, sub-orbicular leaves and a decumbent habit, but the presence of the two wings on the stems of the former species should prevent confusion. When flowering, the small, 10 mm long, white flowers of *Z. pterocaule* distinguishes it from *Z. cordifolium* which has yellow, prominently marked flowers of 14—18 mm in length. The distribution of these two species sometimes overlap.

Distribution and ecology

Z. pterocaule has a small distribution along the lower Orange River basin (Figure 7.6.3). In Namibia it is found at Schakalberg and between the confluence of the Boom and Dabimub rivers with the Orange River. In the Northern Cape it grows on Cornellskop and at Annisfontein, on the western side of the Richtersveld National Park. In Namibia it occurs in vegetation classified as **Succulent Karoo** characterised by chamaephytic dominance (Irish 1994). In the Northern Cape it occurs in

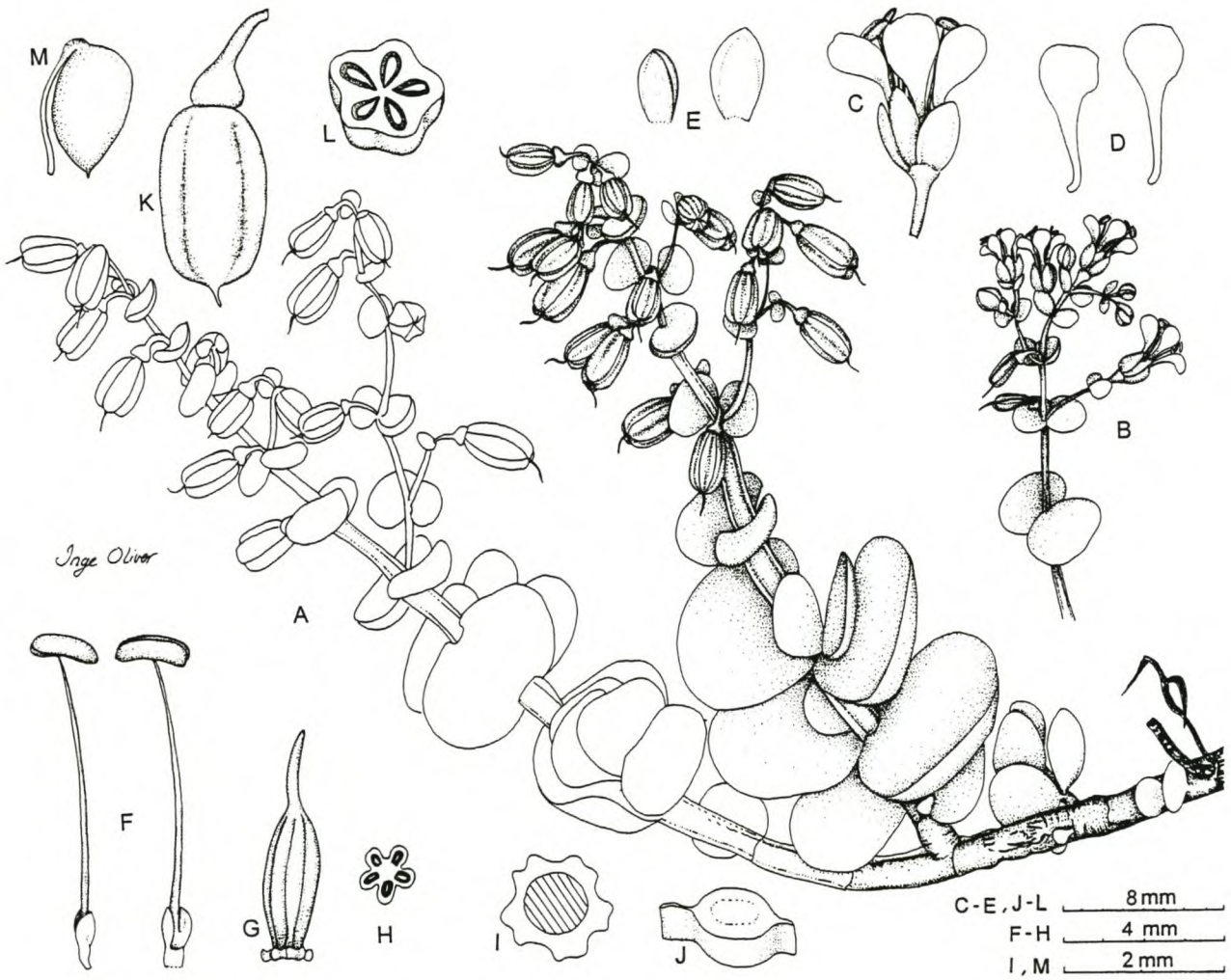


Figure 7.6.1. *Z. pterocaule, Van Zyl 4478.* A, fruiting branch, life-size; B, flowering twig, life-size; C, side-view of flower; D, petals; F, side-view and dorsal-view of staminal scales; G, side-view of ovary; H, cross section of ovary; I, cross section of nectar disc; J, cross section of young stem; K, fresh fruit; L, cross section of fresh fruit; M, immature seed with funicle.

A

B

Figure 7.6.2. *Z. pterocaule*. A, mature, fresh and succulent fruits, *Van Zyl 4478* (wrongly considered as drupes by some authors); B, mature, dry, disintegrating fruit, *Van Zyl 4568*.

belonging to the Mesembryanthemaceae. Rainfall in both these biomes occurs during the winter months while summers are hot and dry.

Populations of this species are small, consisting of a few, scattered plants, at the most ± 50 individuals. It grows on stony, limestone rich soils, on slight slopes and in dry stream beds, always in association with other *Zygophyllum* species. This species retains almost all of its leaves during droughts in contrast to other *Zygophyllum* species which are drought deciduous. This was established in mid summer in the Richtersveld, when extreme temperatures and water stress is the norm. On Cornellskop, only *Z. pterocaule* had a full complement of leaves, whereas *Z. screiberanum, Z. cordifolium* and *Z. longicapsulare* were leafless. The flowering period is from July to October. Mature fruits and seeds are shed several months later. By mid summer the succulence of its fruits have changed into stickiness. The mericarps which are partially encapsulated by the exocarp, are open from the basal end and hangs upside down like a half open umbrella, still containing some of the seeds which are exposed (Figure 7.6.2). Because of the overall stickiness of all parts of the fruit, it is totally covered by particles of windblown debris, dust or sand, thus protecting the exposed seeds from heat and desiccation. Eventually the fruit disintegrates and the mericarps, containing some of the seeds, are dispersed as a unit. No grazing damage to this species occurs, but because of the small size of populations and the rarity of seedlings or young plants, this species is considered vulnerable.

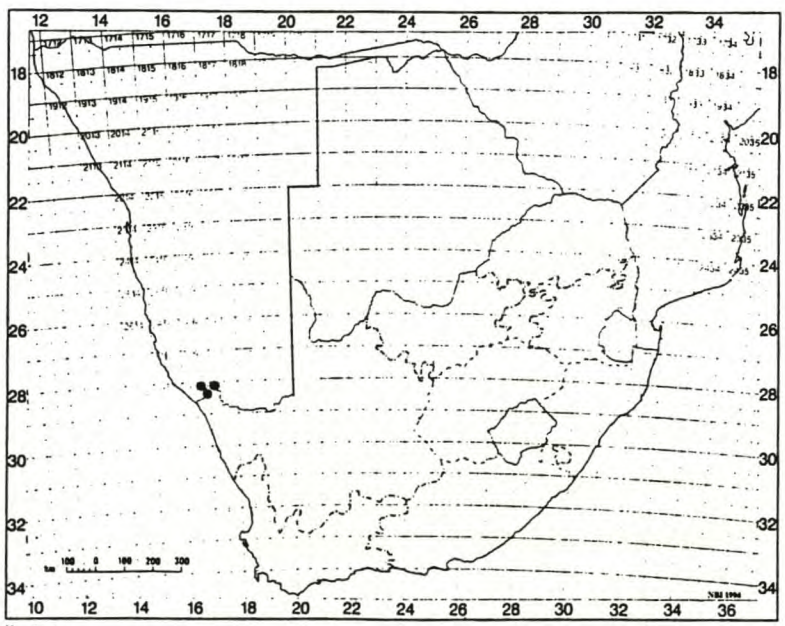


Figure 7.6.3. Geographical distribution of *Z. pterocaule*.

Specimens examined

–2816 (Oranjemund): Schakalberg, in dry stream bed (–BA), *Muller 768* (PRE, WIND); Annisfontein, Richtersveld (–BD), *Jurgens 22160* (PRE); N of Annisfontein, Richtersveld (–BD), *Pillans 5005* (BOL, K); *Hall s.n.* (BOL 26073); Cornellskop, Richtersveld (–BD), *Van Jaarsveld, Forrester & Jacobs 8584* (NBG, PRE); *Van Zyl 4064* (NBG, PRE); *Van Zyl 4136* (B, NBG, PRE, S, WIND); *Van Zyl 4568* (NBG).
–2817 (Vioolsdrif): Between the confluence of Boom and Dabimub rivers along the Orange River (–AA), *Van Zyl 4478*, (NBG, WIND).

§ *Bipartita* Huysst., *Morphologisch-systematische Studien über die Gattung* Zygophyllum……: 59 (1937); El Hadidi: 335 (1980).

Type species: *Z. tenue* Glover.

Diagnostic features

Young stems round or elliptic in cross section, or with a weakly developed to prominent ventral groove
Leaves opposite, bifoliolate, petiolate, leaflets polymorphic, cylindric, oblong, obovate or subrotund
Flowers solitary or two together, axillary (exception *Z. decumbens* with flowers arranged in a cyme)
Nectar disc smooth, prominently 10-lobed, lobes arranged in 5 pairs, each pair orientated outwards and upwards OR disc with slightly raised and sunken areas, the disc sloping slightly towards its periphery
Staminal scales biparted almost to the base
Fruit polymorphic, cylindric, obovoid, rhomboid, transversely oblong, 5-angled, 5-parted or widely winged and sometimes succulent

Of the ten species originally included in § *Bipartita* Van Huyssteen (1937) only *Z. retrofractum* Thunb., *Z. cylindrifolium* Schinz, *Z. clavatum* Schltr. & Diels, *Z. tenue* Glover, *Z. simplex* L., *Z. prismatocarpum* Sond. and *Z. decumbens* Del. var. *decumbens* remain. *Z. maximiliani* Schltr., *Z. densiflorum* Schinz and *Z. dregeanum* Sond. are sunk into the synonymy of *Z. decumbens* Del. *Z. simplex*, originally included by Van Huyssteen (1937) in § *Bipartita*, differs from all members of the

section in being annual or at most biennual and is now removed to the resurrected § *Annua* Engler (1915). The anatomy of its leaves supports this placement. *Z. simplex* has stomatal cells which are level with the surface, lacks dendrites or druses within the leaves and have a centric arrangement of the leaf tissues, whereas the other species in § *Bipartita* have sunken stomatal cells, dendrites or druses occurring throughout the mesophyll and isobilateral or dorsiventral leaves (Kuun 1997). Due to its simple leaves and winged stems, *Z. prismatocarpum* is transferred from § *Bipartita* (all species with bifoliolate leaves) to § *Prismatica*. This treatment correlates with the subdivisions of subgenus *Zygophyllum* where species with simple leaves are placed together in § *Paradoxa*.

With regard to the southern African region, § *Bipartita* is left with five of the original species, which areaugmented by three new species, *Z. applanatum*, *Z. segmentatum* and *Z. turbinatum* and the recently described *Z. chrysopteron*. With regard to § *Bipartita* sensu lato, another three species can be added to § *Bipartita,* namely *Z. depauperatum* Drake, *Z. madecassum* H. Perrier, both from Malagassy and *Z. smitthii* Hadidi from the Gulf of Aden (El Hadidi 1980). Table 7.3 summarizes the characters of the species in § *Bipartita*.

Key to southern African species in § *Bipartita*:

1a Leaves cylindrical in cross section 2

1b Leaves not cylindrical in cross section but with a flattened lamina which can be oblong, obovate or subrotund.....3

2a Robust shrub with strong, thick, segmented branches, only found south of the 27° latitude in the lower Orange River basin.....*Z. segmentatum*

2b Shrublet with thin, white, seasonal branches, found north of the 25° latitude .....*Z. cylindrifolium*

3a Branches plumose, inflorescence a dense scorpioid cyme.....*Z. decumbens* var. *decumbens*

3b Branches not plumose, flowers axillary, single or two together 4

4a Shrubs with repeatedly arched stems.. 5

4b Shrubs without repeatedly arched stems.....7

5a Mature fruit winged, wings membranous, wider than 1 mm 6
5b Mature fruit not winged, when fresh succulent and yellowish, sub-spheroid or ellipsoid, when dry 5-angled or 5-ribbed, ellipsoid or rhomboid, usually with a dark, wrinkled exocarp.....*Z. retrofractum*

6a Mature fruit spherical, widely winged, usually tinted golden-orange when mature.....*Z. chrysopteron*
6b Mature fruit turbinoid, widely winged, usually tinted pink..... ...*Z. turbinatum*

7a Mature fruits 5-parted, transversely oblong .....*Z. clavatum*
7b Mature fruit cylindrical or oblong, longer than wid..... 8

8a Succulent shrublet, usually with a prostrate habit and thick, white, leathery, horizontal branches, fruits succulent and cylindrical when fresh, when dry 5-angled, apex rounded...*Z. applanatum*
8b Rounded shrublet with slender, whitish stems and obovoid, slightly succulent, obovoid, 5-angled fruits with an acute apex.....*Z. tenue*

7.7 Zygophyllum applanatum *Van Zyl* in Van Zyl & Marais, Bothalia 29,2 : 233 (1999). TYPE.— Namibia: Haalenberg, E of Luderitz, *Van Zyl* 3865 (NBG!, holo., B!, PRE!, S!, WIND!).

Small, semi-prostrate shrublet, branched from base, up to 0.2 m in diameter, usually prostrate, but after good rains resprouting from the centre, reaching a height of 0.1 m. *Stems:* old stems white, coriaceous, horizontal, up to 0.1 m long; younger stems greenish-brown, round to elliptical in cross section with a poorly developed ventral groove. *Leaves* opposite, petiolate, glaucous, bifoliolate, on flowering branches gradually reduced to a unifoliolate, sessile state; leaflets articulate,

subrotund or obovate, succulent but flat, apex round, base sometimes cuneate, 4–7 x 4–7 mm; rachis apex filamentous, minute; petiole articulate, cylindrical, 1—3 mm long; stipules widely triangular, membranous, reddish-brown, apex sometimes incised, two on ventral side and two on dorsal side of stems, 0.5 x 2.0 mm, caducous. *Flowers* solitary or two together, axillary. *Pedicel* 1—3 mm long. *Sepals* 5, ovate or obovate, articulate, membranous margined, outer 3 succulent, cucullate, 2.0–3.5 x 1.0–1.5 mm. *Petals* 5, spathulate, apex acute or rounded, base long clawed, white, 3.0–4.0 x 1.5 mm. *Nectar disc* smooth, 10-lobed, lobes vaguely arranged in 5 pairs, the lobes orientated out- and downwards, the disc sloping slightly towards its periphery. *Stamens* 10, filaments terete, 3.5–4.0 mm long; staminal scales 10, bipartite almost to the base, each segment oblong, apex obliquely lobed, margins entire, base asymmetrical, 1.3–1.8 x 0.4–0.5 mm, ± ½ the length of the filament. *Ovary* cylindrical, globulate; style terete; stigma simple. *Fruit* a septicidal, drooping schizocarp; when fresh succulent, cylindrical, usually with faintly visible sutures; when dry becoming brown, cylindrical, 5-lobed, 10.0–12.0 x 3.5–4.0 mm, breaking up in 5 mericarps open on the ventral side. *Seed* pyriform, 4—8 per locule, 1.5 x 0.6 mm, light brown, when immature attached by a long funicle, testa grainy, becoming nearly transparent when wet and producing structured mucilage containing short spiral inclusions that seem to unravel at the apex (Figure 7.7.1).

Diagnostic characters and affinities

Z. applanatum is distinguished by its prostrate habit, by its white, coriaceous, horizontal stems (hence the epithet) and petiolate, succulent leaves with subrotund to obovate bifoliolate leaflets and by its succulent, cylindrical, drooping fruits. It is allied to *Z. clavatum* with regard to leaf and floral characters, although these two species differ with regard to their fruits and habit. *Z. clavatum* is an erect shrub reaching 0.4 m or more in height whereas *Z. applanatum* has a semi-prostrate habit (Figure 7.7.2.A—B) or rarely, after good rains, reach a height of at most 0.1 m. The specific epithet refers to its semi-prostrate habit. When mature and fresh, the brown fruits of *Z. applanatum* are succulent, cylindrical, somewhat 5-angled and 12 x 4 mm in size (Figure 7.7.2.C), whereas those of *Z. clavatum* are depressed ovoid, 5-partite

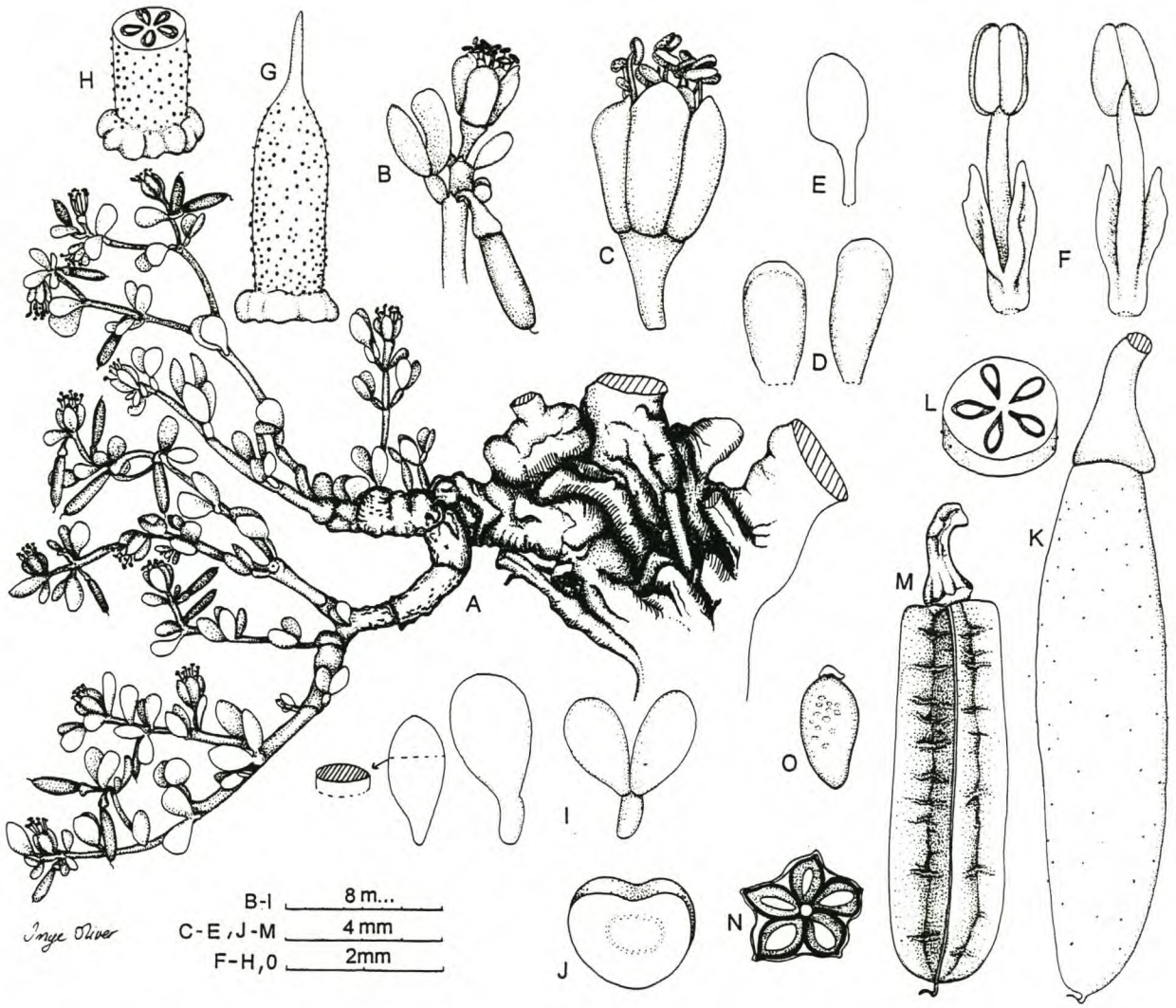


Figure 7.7.1. *Z. applanatum, Van Zyl 4482*. A, flowering and fruiting branch, life-size; B, twig with flower, leaf and fruit; C, side-view of flower; D, sepals; E, petal; F, ventral and dorsal view of staminal scales; G, ovary; H, cross section of ovary; I, range of leaves and cross section of leaf; J, cross section of young stem; K, fresh fruit; L, cross section of fresh fruit; M, dry fruit; N, cross section of dry fruit; O, seed.

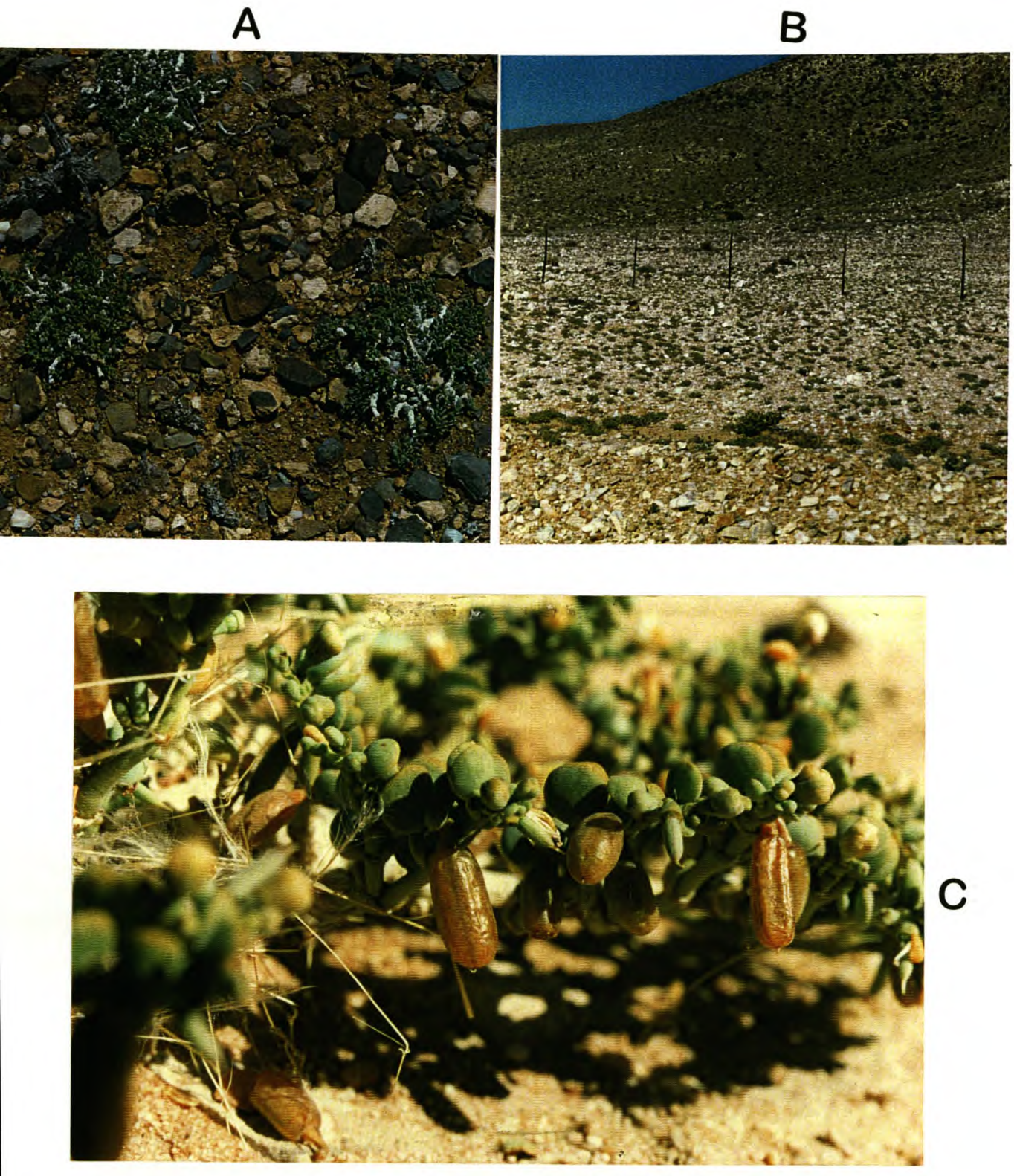


Figure 7.7.2. *Z. applanatum.* A, horizontal habit and white stems as seen from above, *Van Zyl 3881*; B, large population near Witputz, *Van Zyl 4482*; C, nearly ripe, rich brown, succulent fruits *Van Zyl 3886*.

and 2.5 x 4.0 mm in size. *Z. applanatum* has a limited distribution in the south of Namibia and is restricted to the winter rainfall area, whereas *Z. clavatum* has a larger distribution from Sarusas in the north to Port Nolloth in the south and occur in areas receiving rainfall during both winter and summer months. The distributions of these two species sometimes overlap. Table 7.3 summarizes the characters of the species in § *Bipartita*.
Schreiber (1963), considered a specimen of this taxon, Dinter 6614 (B, BOL, Z), to be a hybrid of *Z. clavatum* with another species with longer fruits.

Distribution and ecology

Zygophyllum applanatum is limited to the southern part of Namibia where collections were made around Luderitz, south of Aus and towards Witputz and Rosh Pinah (Figure 7.7.3). The vegetation in this area is classified as **Succulent Karoo Biome** and is dominated by chamaephytes (Irish 1994). Rainfall occurs during winter months and occasional light snowfalls occur on mountains near Aus. The average annual precipitation is low and ranges from 40 to 90 mm. Summers are very hot and dry with frequent periods of drought. In the restricted areas belonging to the Diamond Mining Groups where farming activity is absent, populations consisting of hundreds of plants (Figure 7.7.2.B), including many seedlings and young plants, occur on chalky, desert flats often in association with other *Zygophyllum species*. *Z. applanatum* is palatable though, because in the sheep farming areas around Aus, plants rarely occur inside grazing camps whereas on road sides they are common. *Z. applanatum* is drought deciduous in response to water stress. The flowering and fruiting periods are from August to December. The succulent nature of the fruits delay dehiscence which usually occurs several months after flowering. Because of the large size of populations and the indirect protection of its habitat by the Diamond Mining Groups, this species seems not threatened at present.

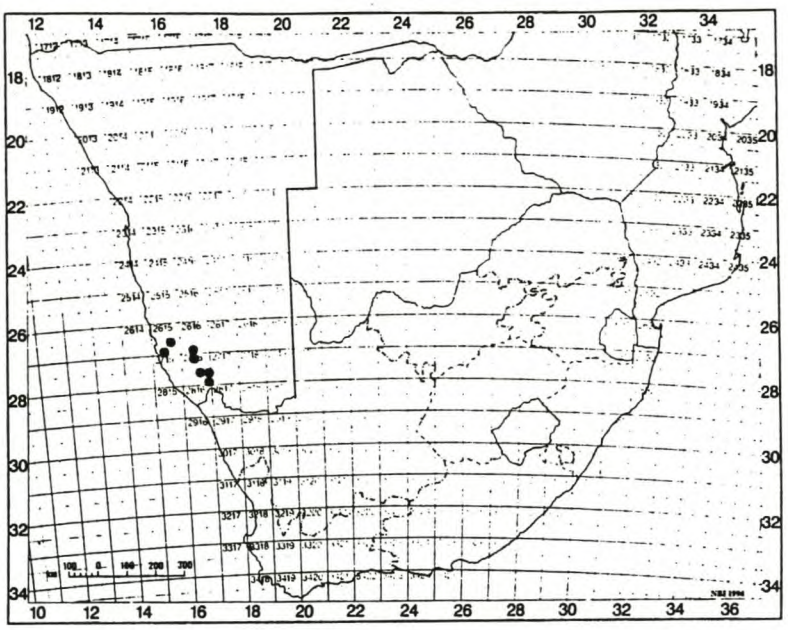


Figure 7.7.3. Geographical distribution of *Z. applanatum.*

Specimens examined

–2615 (Luderitz): Hills E of Grillenthal, S of Luderitz (–CD), *Van Zyl 3879* (NBG, PRE, WIND); 14 km S of Grasplatz, towards Grillental (–CD), *Van Zyl 3868* (NBG, PRE); Haalenberg, E of Luderitz (–DA), *Dinter 6614* (B, BOL, Z), *Van Zyl 3865* (B, NBG, PRE, S).

–2616 (Aus): Kubub 15, Tsamvlakte, S of Aus (–CD), *Van Zyl 3881* (NBG, PRE).

–2716 (Witputz): Arutal 25, 28 km S of Aus (–AB), *Van Zyl 3886* (B, NBG); Kuckaus (–AB), *Dinter* 3724 (B); Witputz (–DA), *Dinter 8078a* (B); Arimas 83, NE of Rosh Pinah (–DB), *Van Zyl 4482* (NBG, PRE, WIND); Plains at entrance to Rosh Pinah (–DD), *Van Zyl 4470* (B, NBG, PRE, S, WIND).

7.8 **Zygophyllum clavatum** *Schltr. & Diels* in Schultze, Aus Namaland und Kalahari.: 705 (1907); Schlechter & Diels: 150 (1910); Huysst.: 60 (1937); Schreib.: 73 (1963); A.Schreib. in Merxm.: 15 (1966). TYPE - Namibia: Namib, Angra Pequena, *Schultze 8a* (B†); not traced in the following Herbaria either: B, C, GB, H, KIEL, L, M, MB, UPS, W, Z. 10 m N of Swakopmund *Van Zyl 3788* (NBG, neo, designated here, PRE, WIND);

Zygophyllum breviarticulatum *Engl.*, nom. nud. Feddes. Repert. 25: 209 (1928), *Schafer 594*,

Zygophyllum densum *Dinter*, nom. nud. Jammerbucht, Pomona, *Dinter 6394* (B!, S); Burchell 1584 (K!).

Erect, densely branched shrublet, reaching a height of 0.5 m and a diameter of 1.0 m, hummock forming in areas with moving sand particles. *Stems:* old stem nearly black to light gray, coriaceous, nude, internodes short; young stems greenish-brown, densely leafy, round to elliptical in cross section with a weakly developed ventral groove. *Leaves* petiolate, opposite, bifoliolate, on flowering branches reduced to unifoliolate, simple and sessile state; leaflets articulate, asymmetrical, glaucous or green, obovate, clavate, succulent, usually flat, apex round, base often cuneate, 4–9 x 2.0–4.5 mm; rachis apex filamentous, minute; petiole articulate, cylindrical, 1—5 mm long; stipules triangular, with a brownish base and membranous, lacerated margins, two on ventral and two on dorsal side of stem, caducous, 0.5 x 2.0 mm. *Flowers* solitary or 3 together, axillary. *Pedicel* 2—3 mm long, in fruit up to 7 mm long. *Sepals* 5, ovate to obovate, membranous margined, outer ones succulent, cucullate, 2.0–3.5 x 1.5 mm. *Petals* 5, spathulate, apex round, base with long claw, white, 3–4 x 1–2 mm. *Nectar disc* fleshy, smooth, regularly 10-lobed, the lobes orientated out- and downwards, the disc sloping slightly towards its periphery. *Stamens* 10; filaments terete, 3—4 mm long; staminal scales 10, alternately differently orientated, bipartite almost to the base, each segment ovate or oblong, apex rounded or obliquely lobed, margins entire, base asymmetrical, 0.8–1.5 x 0.2–0.5 mm, ± 1/3 the length of the filament. *Ovary* depressed ovoid, 5-parted, apex globulate; style terete; stigma simple. *Fruit* a 5-parted, depressed ovoid, erect, septicidal schizocarp, 1.2–2.0 x 4–6 mm, breaking up in 5, spongy, mericarps. *Seed* pyriform, 0—2 per locule, light-brown, 1.5–1.8 x 0.7–1.0 mm, when immature attached with long funicle, testa grainy, nearly transparent when wet and producing structured mucilage with short, spiral inclusions that seem to unravel at the apex (Figure 7.8.1).

Diagnostic features and affinities

Z. clavatum is recognized by its petiolate, bifoliolate leaves with obovate or clavate leaflets (hence the specific epithet), by its 5-parted, depressed ovoid fruits which

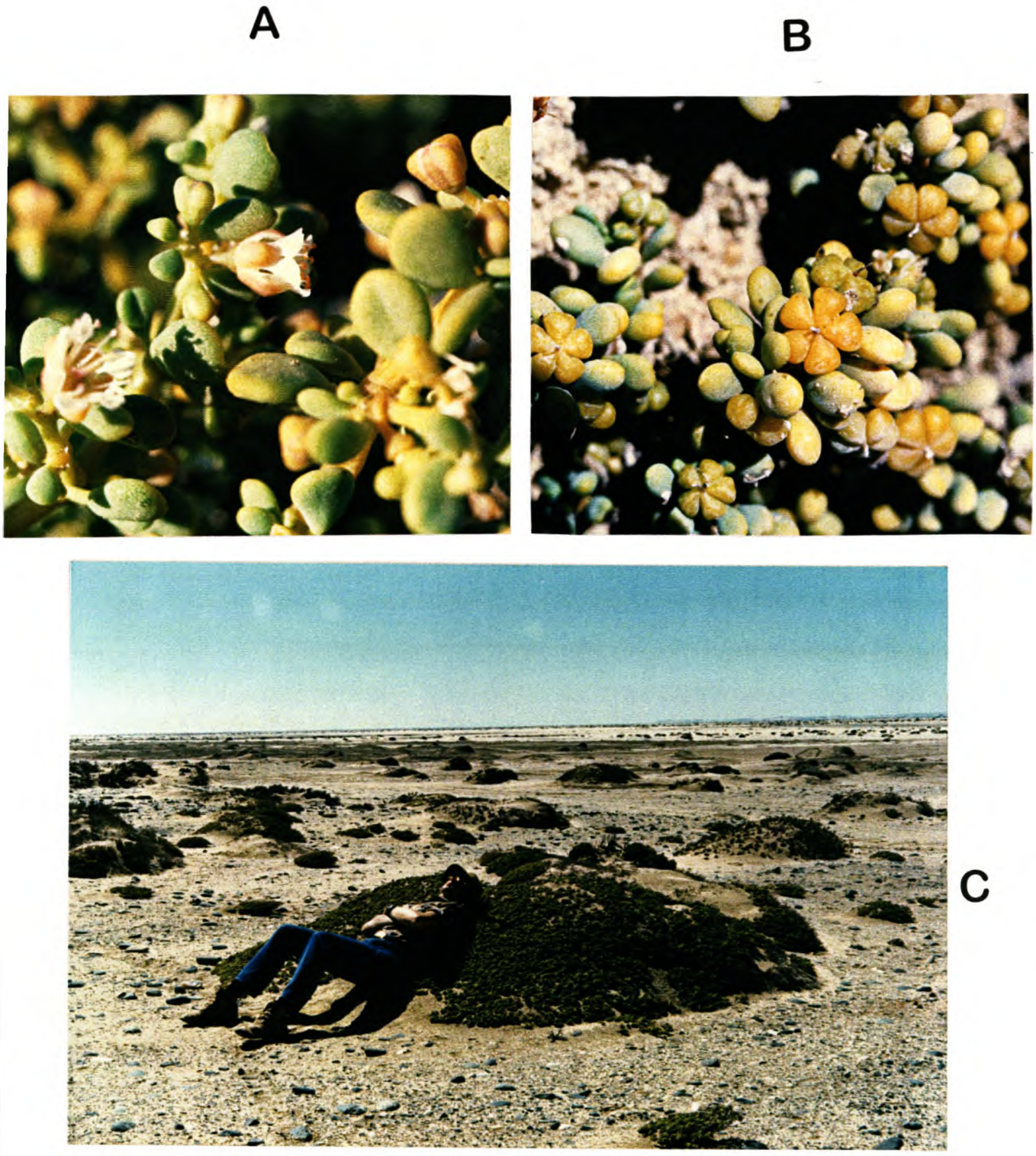


Figure 7.8.1. *Z. clavatum*. A, twig with flowers a bud and leaves, *Van Zyl 3878*; B, twigs with leaves and fruits seen from above, *Van Zyl 3878*; C, hummock forming habit near Swakopmund, *Van Zyl 3788*.

break up in 5, spongy, very often seedless mericarps and by its hummock-forming habit in areas with moving sand particles (Figure 7.8.1.B—C). It is allied to *Z. applanatum* with regard to leaf and floral morphology. Both species have glaucous, succulent, petiolate leaves of more or less the same size, those of *Z. clavatum* with obovate or clavate leaflets and those of *Z. applanatum* with obovate or subrotund leaflets. Both species have similar, small, white flowers with spathulate petals of nearly similar dimensions and succulent, cucullate outer sepals (Figure 7.8.1.A). They are distinguished from each other by their different habits and fruits. *Z. clavatum* is an erect shrub reaching 0.5 m or more in height, although, when reaching this height, it is usually in a hummock habit with most of the stems covered by sand whereas *Z. applanatum* is semi-prostrate and usually less than 0.1 m in height. The mature, dry fruits of *Z. clavatum* are 5-parted, and depressed ovoid, 2.5 x 4.0 mm in size (Figure 7.8.1.B). Those of *Z. applanatum* are succulent, brown in colour, 5-lobed, cylindrical and 12 x 4 mm in size (Figure 7.7.2.C). The fruits of *Z. clavatum* resemble those of *Z. simplex,* but the latter is a herb distinguished by its prostrate, mat forming habit. Table 7.3 summarizes the characters of the species in § *Bipartita*.

Distribution and ecology

Z. clavatum occurs in a narrow strip along the Namibian and Northern Cape coastline from Sarusas in the north to Port Nolloth in the south (Figure 7.8.2). Many collections were made on the first dunes in close proximity to the sea, where this species tolerates brackish conditions and acts as sand binders forming prominent hummocks (Figure 7.8.1.C). This hummock forming ability was also recorded by Williamson (1997). Coastal, hummock forming populations are large, consisting of hundreds of plants of all sizes and ages. Inland, in the desert, smaller communities of *Z. clavatum* occur near low mountains south of Luderitz, Kowisberg and Haalenberg, Klinghardt Mountains, Boegoeberg and Schakalberg. Here, on a substrate of coarse, granitic sands at the base of outcrops, no hummock formation occurs. In the northern part of its distribution range *Z. clavatum* occurs in vegetation classified as **Desert Biome** with a very low summer rainfall, supplemented with moisture from regular coastal fogs (Irish 1994). In the southern part of its range,

from Luderitz to Port Nolloth, the vegetation is classified as **Succulent Karoo Biome** (Irish 1994), which falls within the winter rainfall area, but with hot, dry summers. Flowers are visited by bees and ants, while grazing by Gemsbok and Springbok is mentioned on herbarium labels. The flowering and fruiting occur throughout the year. Although there is no scarcity of fruits, in nature or on herbarium sheets, most mericarps are empty which is probably an indication of a lack of pollinators. Flowers stay open at night. Due to the large size of most of the populations and the indirect protection of its habitat in the Diamond Mining areas, this species is probably not threatened at present.

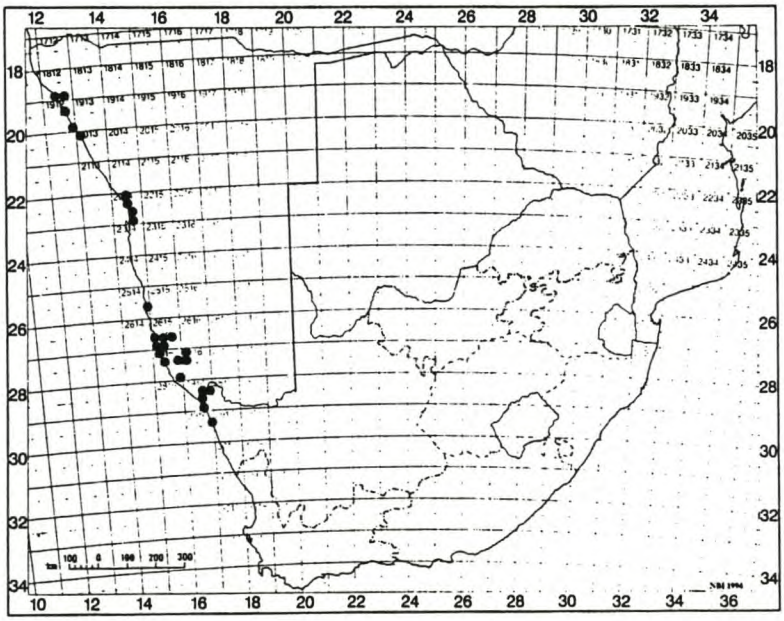


Figure 7.8.2. Geographical distribution of *Z. clavatum*.

Specimens examined

–1812 (Sanitatas): Granite ridge at Sarusas East (–CD), *Giess 9415* (WIND); 2 m inland from Rocky Point (–DC), *Van Hoepen 4* (PRE).

–1912 (Hoanib Mouth): 300 meters from sea at Mowe Point (–BC), *Cooper 6* (WIND); Terrace Bay (–DD), *Du Plessis s.n.* (NBG).

–2013 (Unjab Mouth): 16 km N of Torrabaai (–AA), *Giess 8001* (WIND); *Jancowitz 391* (WIND); Unjab mouth (–AA), *December 316* (WIND), *Muller & Loutit 1184* (WIND), *Craven 271* (WIND).

–2214 (Swakopmund): Strand at Hentiesbaai (–AB), *Giess 3553* (PRE, WIND); 5 m E of Hentiesbaai (–AB), *Merxmüller & Giess 1729* (PRE, WIND); 18 km S of Hentiesbaai (–AD), *Van Zyl 3790* (BOL, NBG, PRE); At Wlotzkabaken (–AD), *Giess 9135* (WIND); 10 m N of Swakopmund (–AD), *Jensen 41*

(WIND); *Giess 3413* (WIND); *Van Zyl 3788* (NBG, PRE, WIND); On beach near mouth of Swakoprivier (–DA), *Pole Evans s.n.* (PRE *45826*); 5 m S of Swakopmund (–DC), *Van Vuuren 991* (WIND); Near sea, Walvisbaai (–DC), *Compton BOL 49349* (BOL).

–2514 (Spencer Bay): Nordhuk, Spencer Bay (–DB), *Giess & Robinson 13184* (WIND).

–2615 (Luderitz): Angra Pequena (–CA), *Marloth 4625* (PRE), *Galpin & Pearson 7574* (PRE, SAM); Between Grossebuch and Griffeths Bay turn off (–CA), *Van Zyl 3878* (NBG, PRE, WIND); Granite mountain near Bogenfels (–CA), *Schafer 17* (PRE); Luderitzbucht (–CA), *Volk 12869* (WIND), *Ordman BOL 49348* (BOL), *Range 1751* (SAM); Diaz Point, Luderitz (–CA), *Van Vuuren 721* (WIND); Kowis mountains, 20 m E of Luderitz (–CB), *De Winter & Hardy 7915* (PRE, WIND), *Giess 2354* (WIND); Brackflachen at Elizabeth Bay (–CC), *Merxmüller & Giess 2354* (PRE, WIND); 17 km S of Grasplatz towards Grillental (–CD), *Van Zyl 3869* (NBG, PRE); Near Grillental (–CD), *Van Zyl 3872* (BOL, NBG); Haalenberg, E of Luderitz (–DA), *Merxmüller & Giess 3119* (WIND).

–2715 (Bogenfels): Jammerbucht, Pomona (–AA), *Dinter 6394* (B, BOL, NBG, Z); Dolomite outcrops at Bogenfels (–AD), *De Winter & Giess 6213* (WIND); Hill to SW of Hochster, Klinghardtsberge (–BD), *Oliver 10236* (NBG, WIND); On rocks at Western Buchuberg (–DD), *Williamson 2705* (BOL).

–2716 (Witputz): SW slopes of Tsausberg (–AA), *Wendt B/10* (WIND); E of main peak of Heioab area (–AC), *Oliver 10227* (NBG).

–2816 (Oranjemund): Jakkalsberge, Rooi Lepel, LUS (–BC*), De Winter & Giess 6168* (WIND); Schakalsberge, Numies Mine (–BD), *Hardy & Venter 4796* (PRE); ± 4 km from coast, S of Alexanderbay (–DA), *O'Callaghan, Van Wyk & Morley 73* (NBG); 10 km S of Alexander Bay towards Port Nolloth (–DA), *Van Zyl 4075* (NBG); Near Grootderm (–DA), *Leistner 3427* (WIND); Hills E of Grootderm (–DA), *Pillans* 5254 (BOL); Between Beesbank and Brandkaros, NE of Alexander Bay (–DA), *Van Zyl 4073* (NBG, PRE, WIND); Holgatrivier mouth (–DC), *Le Roux & Parsons 10* (NBG); Swartbank area, S of Alexander Bay (–DC), *Van Zyl 4079* (NBG, PRE); Coastline SW of Boegoeberg, W of Rietfontein (–DC), *Le Roux & Ramsay 193* (NBG); Rietfontein Pan, littoral, Alexander Bay (–DC), *Le Roux & Ramsey 197* (NBG, WIND); Near Rietfontein, S of Alexander Bay (–DC), *Van Zyl 4563* (B, BOL, NBG, WIND).

–2916 (Port Nolloth): Port Nolloth (–BD), *Galpin & Pearson 7595* (PRE, SAM).

Without precise locality: *Burchell 1584* (K); Oranjemund Diamond Area, *Williamson 2718* (BOL); Buntfeldschuk, *Dinter 3850* (BOL); Nautilus nordl. - Luderitz, *Merxmüller & Giess 3079* (WIND).

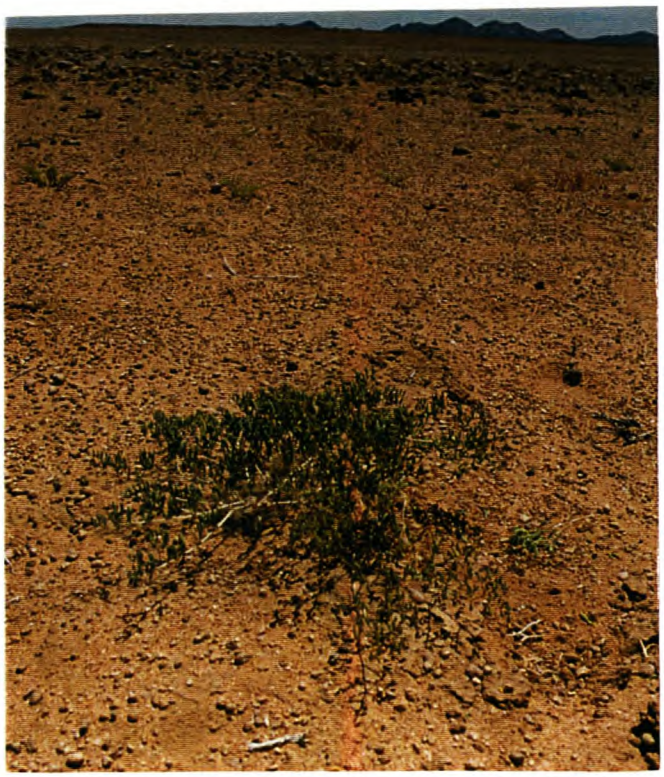
Note: Schreiber, (75, 1973) mapped the distribution of *Z. clavatum* quite correctly, but for a single mistake. She wrongly gave the locality of *Volk 12869* as Grootfonteiner Fläche (M) near Maltahohe. This cannot be correct, because *Z. clavatum* always occurs close to the coastline. I saw a Volk 12869 specimen, but its locality was given as Luderitzbucht which lies well within the distribution area of this species.

7.9 **Zygophyllum cylindrifolium** *Schinz* in Bulletin Herbarium Boissiera. 2, 8: 631 (1908); A.Schreib.: 78 (1963); A.Schreib. in Merxm.: 15 (1966). TYPE - Namibia: On granites at Salem, Hereroland, *Dinter 94* (Z!, holo).

Shrublet with woody base from which thin, spreading, seasonal branches develop, reaching a height of 0.3 m and a diameter of 0.7 m; seasonal branches usually whither partially away during dry periods. *Stems:* old stems rimous, whitish, nude; young stems pale, whitish, leafy, with a prominent ventral groove. *Leaves* opposite, petiolate, bifoliolate, on flowering branches often reduced to unifoliolate or bifid state; leaflets articulate, green, cylindrical, succulent, adaxially shallowly grooved, apex and base obtuse, 8–15 x 2 mm; rachis apex filamentous, minute; petiole articulate, cylindrical, fleshy, shallowly grooved on ventral side, 6—8 mm long; stipules triangular or widely triangular, membranous, white, two on ventral side and usually two or rarely one only on dorsal side of stem, caducous, 0.5 x 2 mm. *Flowers* solitary or rarely two together, axillary. *Pedicel* 5—10 mm long. *Sepals* 5, oblong, membranous margined, outer ones succulent, cucullate, 2.5–3.0 x 1.0 mm. *Petals* 5, spathulate, apex rounded, base with a long claw, white, 4–5.5 x 1.0–1.5 mm. *Nectar disc* fleshy, granular, prominently 10-lobed, lobes arranged in 5 pairs, each pair orientated upwards and outwards. *Stamens* 10; filaments terete, 3.0—3.5 mm long; staminal scales 10, alternately differently orientated, bipartite almost to the base, each segment oblong, apex rounded or obliquely lobed, margins entire, base asymmetrical, 1.5–2 x 0.5–0.6 mm, ± ½ as long as filament. *Ovary* narrowly obovoid and with a tapering apex, 5-lobed, globulate; style terete; stigma simple. *Fruit* a drooping, septicidal schizocarp: when fresh obovoid, with faint sutures visible; when dry, obovoid and 5-lobed, 7.0–8.0 x 3.5–4.0 mm, breaking up in 5, mericarps. *Seed* pyriform, 6—12 per locule, 1.5 x 0.6 mm, pale brown, when immature attached by a long funicle, testa grainy, becoming transparent when wet, producing structured mucilage with short, spiral inclusions which seem to unravel at the apex (Figure 7.9.1).

Diagnostic characters and affinities

Z. cylindrifolium is distinguished by its petiolate, bifoliolate leaves which have cylindrical, succulent leaflets (hence the specific epithet) and by its bleak, spreading, young branches that partially whither away during dry seasons (Figure 7.9.1). It is allied to *Z. segmentatum* with regard to leaf and fruit morphology. Both species have



A

B

Figure 7.9.1. *Z. cylindrifolium, Van Zyl 3794*. A, habit, displaying weak, spreading white, seasonal stems; B, twigs with leaves, buds and flowers.

similar, succulent leaves which differ only in size. The leaves of *Z. cylindrifolium* are the longest (8—12 mm), whereas those of *Z. segmentatum* are shorter (5.0–7.5 mm). They have similar drooping, obovoid fruits with faint sutures visible when fresh, becoming obovoid and 5-lobed when dry. Their fruits are similar in shape to those of *Z. tenue,* but in the latter the fruits are 5-angled and have an acute apex. *Z. cylindrifolium* and *Z. segmentatum* are distinguished from each other by their different habits and distribution areas. *Z. cylindrifolium* is a shrublet with thin, seasonal branches, reaching a height of 0.3 m only (Figure 7.9.1 A) and occurs north of 25° latitude. *Z. segmentatum* is a sturdy shrub with strong, thick, segmented, permanent branches, reaching a height of 0.6 m (Figure 7.10.2.B), occurring in the lower Orange River basin always south of the 25° latitude. Table 7.3 summarizes the characters of the species in § *Bipartita*.

Distribution and ecology

Z. cylindrifolium occurs in the north-western part of Namibia, from Ogams Hills in the north to Sossusvlei in the south (Figure7.9.2). It occurs in vegetation classified as **Desert Biome** next to the coastline and further inland in vegetation classified as **Nama-Karoo Biome** (Irish 1994). It usually occurs below the escarpment on stony or sandy, desert plains or near granite hills or rocky outcrops. Populations consist of scattered individuals which are usually strung out along low lying, dry water courses or against outcrops of any kind where dispersed mericarps with seeds gather and germinate. Both these biomes receive a very low annual summer rainfall which, for the Desert Biome, is substituted by regular coastal fogs. Flowering period is from March to July whereas mature fruits are found later, from October to December. Grazing damage seems minimal. The succulence of the fruits delays the shedding of ripe seeds, which probably explains the lapse of time between flowering and seed shedding. During adverse conditions the younger stems of shrublets dry out or whither away, while only the woody base remain alive. Large numbers of mature schizocarps, or mericarps, containing ripe seeds, remain on the dried out twigs which are blown away and thus dispersed. Because of its large distribution area and large populations this species seems not to be threatened at present.

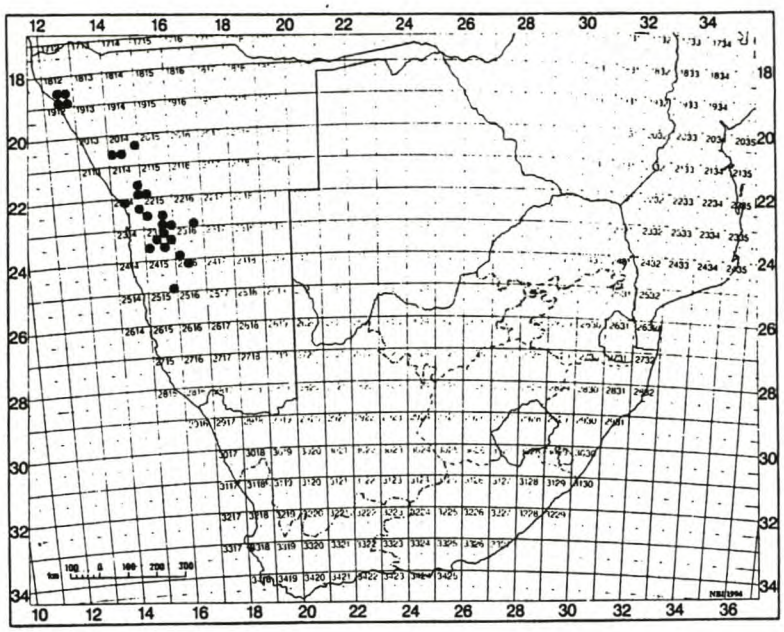


Figure 7.9.2. Geographical distribution of *Z. cylindrifolium*.

Material examined

–1812 (Sanitatas): Ogams Hills (–CB), *Moss & Jacobsen K171* (PRE, WIND); Granite hills 8 M N of Sarusas (–CD), *Giess & Leippert 7467* (WIND); 27 M S of Orupembe, Welwitschiastandort, Sechomibriver (–DA), *Giess & Leippert 7503* (WIND); 25 km S of Purros (–DD), *Viljoen 571* (WIND).
–2014 (Welwitschia): Welwitsch (–BD), *Galpin & Pearson 7593* (PRE, SAM); Mountain slope, S of Twyfelfontein (–CA), *Craven 998* (WIND); Twyfelfontein (–CB), *Schmidt 182* (WIND); On plateau near engrawings at Twyfelfontein (–CB), *Craven 3800* (WIND).
–2114 (Uis): 8 km E of Baken Leeuwater (–DB), *Giess 7881* (WIND); 26 M on Hentiesbaai-Spitzkoppen road (–DD), *Ihlenfield, de Winter & Hardy 3088* (WIND).
–2115 (Karibib): 23 M from Usakos to Great Spitzkop (–CC), *Tölken & Hardy 789* (PRE, WIND).
–2214 (Swakopmund): 22 M E of Hentiesbaai (–AB), *Giess, Volk & Bleissner 5782* (WIND); N of Arandis (–BD), *Craven 1652* (WIND); Quartz hills in Rossing Mountains (–BD), *Jensen 5* (PRE).
–2215 (Trekkopje): In vicinity of Ida Mine, Swakoprivier (–CA), *Kers 1546* (WIND); Salem, district Karibib (–CB), *Dinter 94* (Z); Rooikuiseb, Karibib (–DA), *Giess 3516* (NBG, WIND); Onanis, Karibib (–DC), *Giess 2258* (WIND); Donkerhuk, KAR 91, 18 M W on road Windhoek-Swakopmund (–DD), *Ihlenfield, de Winter & Hardy 3050* (WIND).
–2315 (Rostock): S side of Anachonhirab, Namib-Naukluft Park (–AD), *Van Zyl 3794* (NBG, PRE, WIND), *Ward 175* (WIND); On slope of Inselberg outcrop, Rostock (–BA), *Cresswell 108* (WIND); N side of Kuiseb Canyon, Namib-Naukluft Park (–BD), *Van Zyl 3797* (NBG, PRE); Arusvlei, Namib-

Naukluft Park (–BD), *Van Zyl 3795* (NBG, PRE); Rostock 393, Sandsteenberg (–BD), *Van Zyl 3800* (NBG, PRE); Aruvlei, near Gamsberg turn off (–BD), *Van Zyl 3799* (NBG); Quartz ridge, Hope Mine (–CA), *Giess 3771* (WIND); 123 km E of Swakopmund, 5 km opposite Namib Park boundary (–DA), *Greuter s.n.* (WIND 50316).

–2316 (Nauchas): Tsondab riverbank below Ababes (–CC), *Pearson 9159* (BOL).

–2415 (Sossusvlei): Vreemdelingspoort, Maltahohe (–DD), *Logan 309* (WIND).

–2416 (Maltahohe): Naukloof Mountains at Bulspoort (–AB), *Rodin & Strey 2937* (BOL).

No exact or unknown locality: Namib, Kuiseb, district Swakopmund, *Strey 2600, 2702* (PRE), *Strey 2190*, (PRE, WIND); Altenbrunn, Swakopmund, *Seydel 510* (PRE); Chursberge, on lime, *Seydel 2013* (B); Spitskop plains, *Jensen s.n* (WIND 15958).

7.10 Zygophyllum segmentatum *Van Zyl*, sp. nov. (§ *Bipartita), Z. cylindrifolio* foliis fructibusque affinis sed habitu fruticoso caulibus 10 mm crassis cinereis segmentatis, petalisque oblanceolatis (non habitu fruticuloso, caulibus tenuibus pallidis, petalisque spathulatis) differt. TYPE - Namibia: Between the confluence of Dabimub and Boom rivers with the Orange River, *Van Zyl 4473* (NBG, holo., B, BOL, PRE, S, WIND).

Rounded, many-stemmed, woody shrub reaching a height of 0.6 m and a diameter of 1.0 m. *Stems:* old stems nude, bark dark or light gray, finely cracked, prominently segmented, leafless; young stems smooth, prominently segmented, easily breaking up in parts when dry, brownish or green, leafy, with a prominent ventral groove. *Leaves* opposite, petiolate, bifoliolate, on flowering branches reduced to unifoliolate, sessile state; rachis apex filamentous, minute; petiole articulate, cylindrical, succulent, adaxially shallowly grooved, 3—5 mm long; leaflets articulate, green or glaucous, usually conduplicate, cylindrical, succulent, shallowly grooved on dorsal side, 5.0–7.5 x 2.0–2.5 mm, apex and base obtuse; stipules triangular or widely triangular, membranous, white, two on ventral and two on dorsal side of stems, caducous, 0.5 x 0.5 mm. *Flowers* 1—3 together, axillary. *Pedicel* 4—7 mm long. *Sepals* 5, ovate or oblong, membranous margined, outer ones succulent, cucullate, 2.5–3.0 x 1–2 mm. *Petals* 5, oblanceolate, 3–4 x 0.5 mm, apex rounded, base long clawed, white. *Nectar disc* fleshy, smooth, prominently 10-lobed, lobes arranged in 5 pairs, each pair orientated upwards and outwards. *Stamens* 10; filaments terete, 4.0—4.5 mm long; staminal scales 10, bipartite almost to the base, alternately

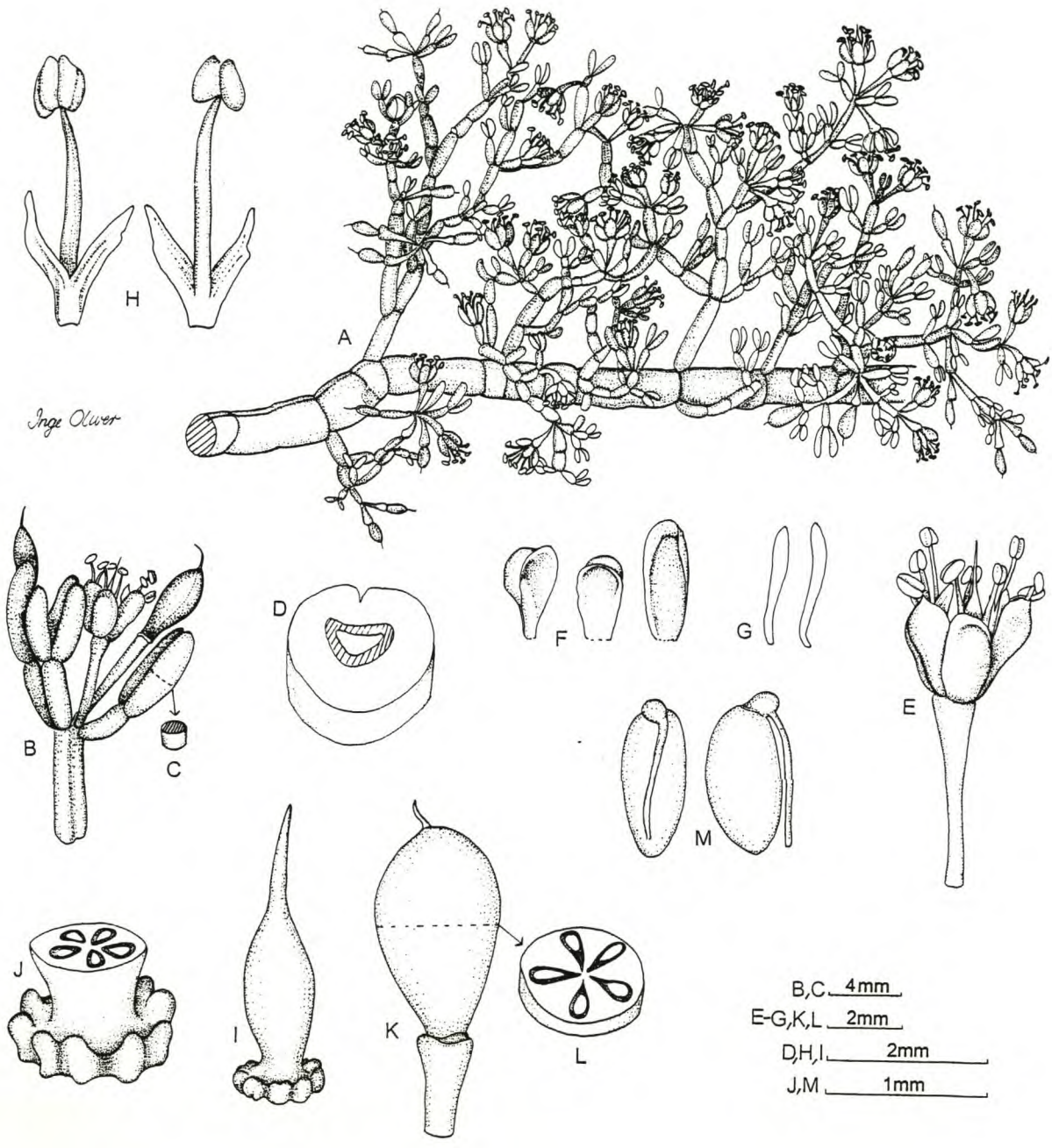


Figure 7.10.1. *Z. segmentatum, Van Zyl 4473.* A, flowering and fruiting branch, life-size; B, twig with flowers, leaves and immature fruit; C, cross section of leaflet; D, cross section of young stem; E, open flower; F, sepals; G, petals; H, dorsal and ventral view of staminal scale; I, ovary; J, cross section of ovary; K, immature fruit; L, cross section of immature fruit; M, immature seed with long funicle.

Figure 7.10.2. *Z. segmentatum, Van Zyl 4473*. A, flowers, leaves and immature fruits; B, habit near the Orange River.

differently orientated, each segment oblong, apex obtuse or obliquely lobed, margins entire, base asymmetrical, 2.0 x 0.5 mm, ± ½ the length of the filament. *Ovary* narrowly obovoid, 5-lobed; style terete; stigma simple. *Fruit* a drooping, septicidal schizocarp; when fresh succulent, obovoid with faint sutures visible; when dry 5-lobed, 5.5–6.0 x 3.5 mm, breaking up in 5 mericarps. *Seed* pyriform, 4—7 per locule, 1.5 x 0.5 mm, light-brown, when immature attached by a long funicle, testa grainy, becoming transparent when wet and producing structured mucilage with short, spiral inclusions that seem to unravel at the apex (Figure 7.10.1—2).

Diagnostic characters

Z. segmentatum is distinguished by its prominently segmented, old as well as young stems, (hence the specific epithet), by its petiolate, bifoliolate leaves which have cylindrical leaflets and by its oblanceolate petals. Other members of § *Bipartita* have spathulate petals with long claws or obovate petals with shorter claws. *Z. segmentatum* is allied to *Z. cylindrifolium* with regard to leaf and fruit morphology. They have similar, succulent, cylindrical leaflets (Figure 7.10.2.A and 7.9.1.B), those of *Z. segmentatum* are 5—7 mm long and those of *Z. cylindrifolium* are longer, 8—12 mm. Both species have obovoid, drooping fruits which are succulent when fresh with faint sutures visible and when mature become obovoid and 5-lobed (Figure 3.11). The shape of their mature fruits resembles those of *Z. tenue,* but differs from it by being 5-lobed and not 5-angular. *Z. segmentatum* and *Z. cylindrifolium* are distinguished from each other by their different habits. *Z. segmentatum* is a sturdy shrub of up to 0.6 m high with strong, thick, segmented branches (Figure 7.10.2.B), whereas *Z. cylindrifolium* is a shrublet, only 0.3 m high with thin, spreading branches (Figure 7.9.1.A). They occur in different areas. *Z. segmentatum* is found in the lower Orange River basin, south of the 27° latitude and *Z. cylindrifolium* occurs north of the 25° latitude. Table 7.3 summarizes the characters of the species in § B*ipartita*.

Distribution and ecology

Z. segmentatum is limited to a small area in the lower Orange River basin (Figure 7.10.3). In Namibia collections were made at Spitskop and Namuskluft farms near

Rosh Pinah and in the extremely arid, dry watercourses running into the Orange River, from Lorelei Mine in the west to as far east as the Fish River's confluence with the Orange River The substrate is slate or quartz slopes or rocky, chalky stream beds. The vegetation in this area is classified as **Succulent Karoo Biome** (Irish 1994), which receives a low, winter rainfall and experiences extreme summer aridity. A single collection was made south-east of Sendelingsdrift in the Northern Province of South Africa, in vegetation also classified as **Succulent Karoo Biome** and further refined as Upland Succulent Karoo (Hoffman 1996). Substrates are rich loamy sands or clays derived from decomposed granite and gneiss. Populations are small, consisting of up to 20 individuals with older, younger and juvenile plants occurring together. No grazing damage occurs. Younger plants appear more lush, with all parts slightly larger than those of the older shrubs. Only one collection with flowers was made in November, whereas mature fruits were collected in February. The succulent nature of the fruits probably delays ripening, which could take several months and explains why mature fruits were only collected as late as February. Due to the small size of the populations and its limited distribution range, this new species is considered vulnerable.

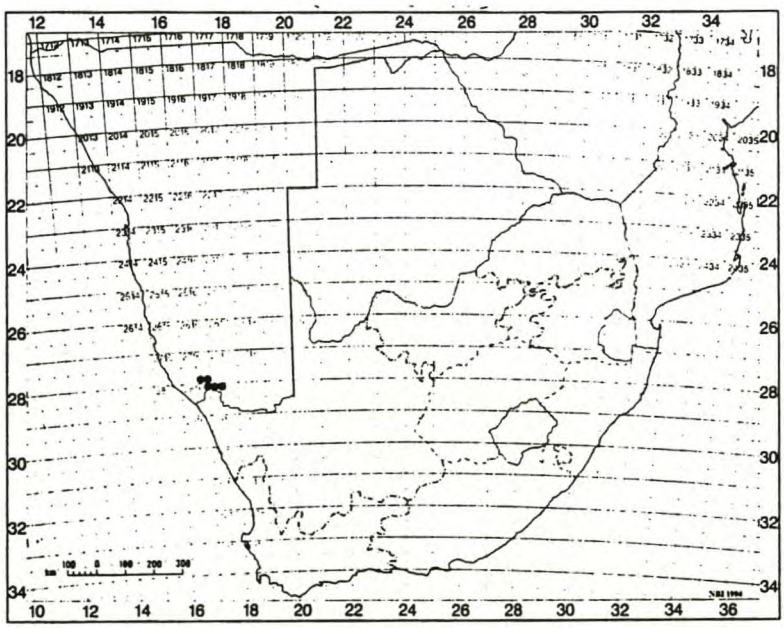


Figure 7.10.3. Geographical distribution of *Z. segmentatum*.

Material examined

–2716 (Witputz): Spitzkop 111, 6 km N of Rosh Pinah (–DC), *Van Zyl 3898* (NBG, PRE); E side of farm Namuskluft, LU 88 (–DD), *Giess, Volk & Bleissner 5362* (PRE, WIND).
–2816 (Oranjemund): Kahanstal (–BB), *Dinter 8066* (BM, BOL, Z); Shale mountain slopes at Kahanstal, 8 m NW of Loreley (–BB), *Merxmüller & Giess 3331* (PRE); At pumpstation of Rosh Pinah, on N banks of Orange River (–BB), *Van Zyl 3910* (NBG, PRE); In granite, N of Sendelingsdrift (–BB), *Mittendorf 72* (WIND); State ground at Lorelei Mine (–BB), *Van Zyl 4345* (NBG, PRE); On brackish soil between hills SE of Sendelingsdrift (–BB), *Pillans 5004* (BOL).
–2817 (Vioolsdrif): Blokwerf, between the confluence of Fish and Dabimub rivers with the Orange River (–AA), *Van Zyl 4379* (NBG); Between the confluence of Dabimub- and Boom rivers with the Orange River (–AA), *Van Zyl 4333* (B, BOL, NBG, PRE, S, WIND); ± 6 km S of Suidewind pump on farm Mara (–AB), *Craven 2894* (WIND).

7.11 **Zygophyllum tenue** *Glover* in Annals of the South African Museum, 9 : 172 (1913); Huysst.: 60 (1937); A.Schreib.: 110 (1963); A.Schreib. in Merxm.: 19 (1966). Two syntypes mentioned by Glover: Sandy plains a little north of Ganus, *Pearson 4500* (BOL!, lecto., designated here, K!, PRE!, Z!); Sandy plains at Schakalskuppe, *Pearson 4257*(K!).

Note: the nomen nudem **Z. dinteri** *Schltr.* in Engl., Pflanzen. Afr.: 3,1 : 732 (1915) and l.c. 209 (1928) based on *Dinter 1029* (B), pro parte, was included in *Z. tenue* by A.Schreib. (1963), but I cannot express an opinion on this matter since I have not yet traced this specimen.

Rounded shrublet, branched from a woody base, reaching a height of 0.4 m and a diameter of 0.5 m. *Stems:* old stems rimous with dark gray bark; young stems slender, straight, smooth, white and with a prominent ventral groove. *Leaves* opposite, petiolate, bifoliolate; leaflets articulate, glaucous, asymmetrical, obovate or oblong, succulent, apex obtuse, mucronate when young but hardly so when mature or succulent, base cuneate or obtuse, 5–7 x 2–3 mm; rachis apex filamentous, minute; petiole articulate, terete, fleshy, adaxially grooved, 1—3 mm long; stipules ovate, membranous, white, margins lacerate, two on ventral and two on dorsal side, 0.5 x 0.5 mm, caducous. *Flowers* solitary, axillary. *Pedicel* 1—2 mm long. *Sepals* 5, oblong, membranous margined, outer ones slightly succulent, cucullate, 3.0–3.5 x

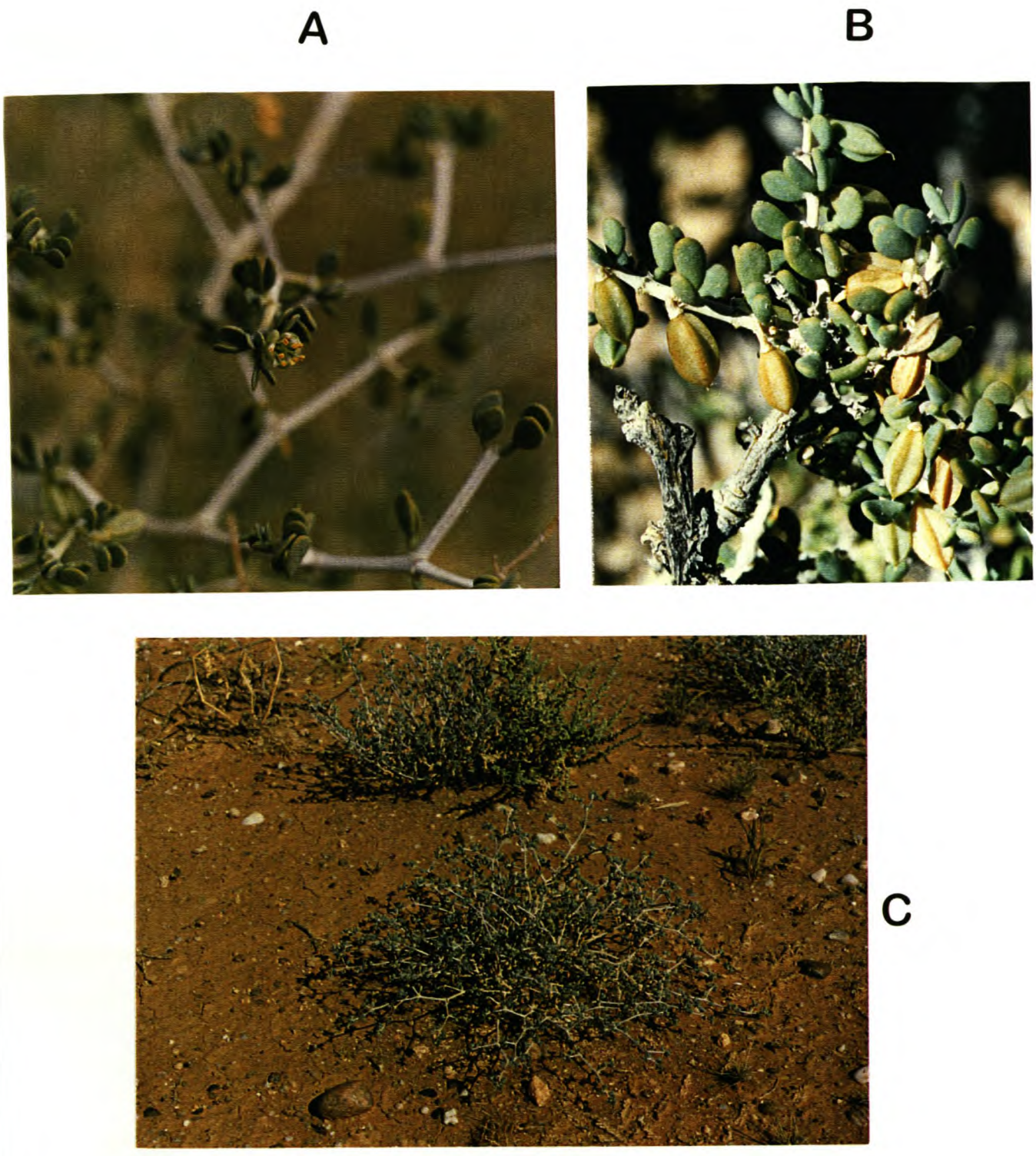


Figure 7.11.1. *Z. tenue*. A, twig with a flower, petiolate leaves and prominently white stems displaying a ventral groove, *Van Zyl 3758*; B, twig with fruits, Van Zyl 3828; C, habit NE of Keetmanshoop, *Van Zyl 3774*.

1.5 mm. *Petals* 5, spathulate, apex obtuse, base long-clawed, white, 4.0 x 1.5 mm. *Nectar disc* fleshy, smooth, prominently 10-lobed, lobes arranged in 5 pairs, each pair orientated upwards and outwards. *Stamens* 10; filaments terete, 4.0—4.5 mm long; staminal scales 10, bipartite almost to the base, each segment oblong, apex rounded or obliquely lobed, margins entire, base asymmetrical, 1.5 x 0.5 mm, ± 1/3 the length of the filament. *Ovary* narrowly obovoid, with a tapering apex, 5-lobed, upper half globulate; style terete; stigma simple. *Fruit* a drooping, slightly succulent, obovoid, 5-angled septicidal schizocarp with an acute apex, 5–7 x 2.5–3.5 mm, breaking up in 5 mericarps. *Seed* pyriform, 1—4 per locule, 1.8 x 0.8 mm, light-brown, when young attached by a long funicle, testa grainy, becoming transparent when wet and producing structured mucilage with short, spiral inclusions that seem to unravel at the apex (Figure 7.11.1. A–C).

Diagnostic characters and affinities:

Z. tenue is recognized by its smooth, white, young stems which have a prominent ventral groove (Figure 7.11.1.A), by its petiolate, bifoliolate leaves which have asymmetrical, obovate or oblong leaflets (Figure 7.11.1.A—B) and by its drooping, non-succulent, obovate, 5-angled fruits (Figure 7.11.1.B). It resembles *Z. cylindrifolium* and *Z. segmentatum* with regard to fruit morphology. Their fruits are obovoid in shape, those of *Z. tenue* become 5-angled when dry, those of the others are 5-lobed when mature. These three species are distinguished by their different leaflets. The leaflets of *Z. segmentatum* and *Z. cylindrifolium* are cylindrical whereas those of *Z. tenue* are obovate or oblong. Although there is no doubt about its inclusion in § *Bipartita*, *Z. tenue* has no close allies and stands somewhat on its own within the section. Why the name *tenue* was given to this species is unknown. Table 7.3 summarizes the characters of the species in § *Bipartita*.

Distribution and ecology

Z. tenue is widespread in the interior southern half of Namibia. Its range extends into western Botswana and it has an outlyer population in the Northern Cape Province (Figure7.11.2). This species probably has a more frequent occurrence in

Botswana and the Northern Cape, but is easily overlooked by collectors because of its insignificant flowers and hidden fruits. In Namibia it occurs in vegetation classified as **Nama Karoo Biome,** in the western part of its range and in the eastern part of its range **Savanna Biome** (Irish 1994). The outlier population in the Northern Cape Province occurs at Vanwyksvlei in a vegetation classified as **Nama Karoo Biome**: Bushmanland Nama Karoo (Hoffman 1996). It occurs on grassy plains, limestone flats, brackish low lying areas, quartz or dolerite ridges, shale, and sand over limestone. Rainfall occurs during summer and autumn, but towards the southern part of its distribution, rainfall occurs throughout the year. Populations include young and mature individuals scattered over large areas. Grazing damage occur. Grazed plants lack the branched, white-stemmed young growth, topping most shrubs. Flowering period is from November to May, while fruits remain on shrubs for a much longer period. Table 7.3 summarizes the characters of the species in § *Bipartita*.

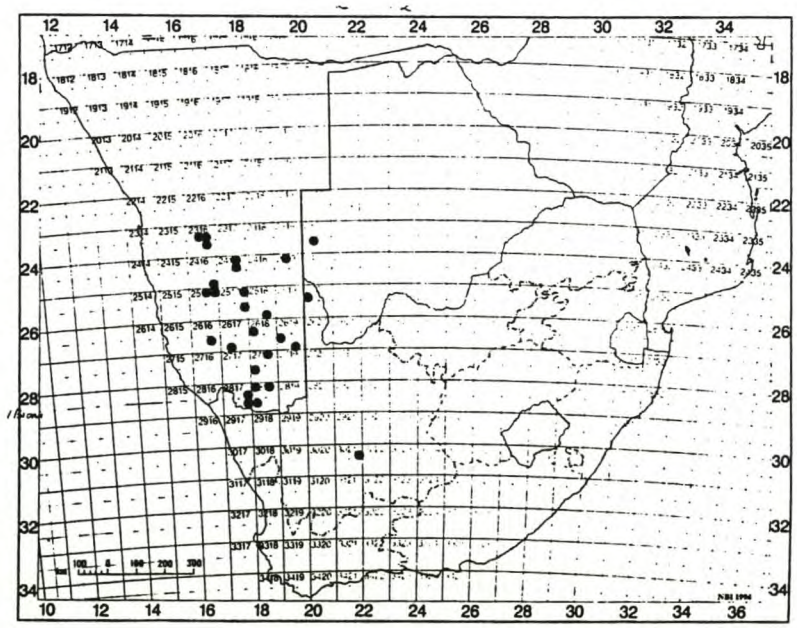


Figure 7.11.2. Geographical distribution of *Z. tenue*.

Material examined

–2316 (Nauchas*)*: Farm Weisenfels: REH 22 (–AD), *Volk 11484* (WIND); Sandy flats on farm Rothenstein: REH 43 (–BC), *Giess 12446* (PRE, WIND); Moutonsvlei: REH 323 (–DA), *Volk 11459* (WIND).

–2320 (Ukm): At the airstrip on ranch 23 (–CB), *Skarpe S-354* (PRE, UPP).

–2416 (Maltahohe): Brackflaeche on farm Cristiania: MAL 44 (–DD), *Giess 8798* (WIND); Maltahohe district (–DD), *Basson 254* (PRE).

–2417 (Mariental): 1 km S of dolomite ridge on farm Gurus: REH 150 (–BA), *Giess 8291* (WIND); Pans S of Kalkrand on farm Narib: GIB 106 (–BC), *Giess, Volk & Bleissner 5615* (WIND).

–2419 (Aranos): Bottom of calcarous pan on Mooigelee, 14 m E of Aranos (–AB), *Van Vuuren & Giess 1068* (WIND).

–2516 (Helmeringhausen): On farm Kleinfontein Nord 82, 48 km S of Maltahohe (–BA/BB), *Van Zyl 3805* (NBG, PRE, WIND); Flats on Grootfontein: MAL 91 (–BB), *Volk 12877* (WIND); Farm Lisbon, part of Grootfontein: MAL 91 (–BB), *Giess 10691* (WIND).

–2517 (Gibeon): Between Falkenhors and Die Kalk, 70 km S of Mariental on B1 (–BB), *Van Zyl 3780* (NBG, PRE, WIND); Farm Gevetamas: KEE 11 (–DB), *Giess, Volk & Bleissner 6855* (WIND).

–2518 (Tses): Shirley 189, NE of Keetmanshoop (–DC), *Van Zyl 3774* (NBG, PRE, WIND).

–2520 (Mata Mata): Grasvlei wind pump in Kalahari-gemsbok Nasional Park (–AC), *Van Rooyen 3877* (PRE).

–2616 (Aus): Sandy plain at Schakalskuppe (–DA), *Pearson 4257* (BOL).

–2617 (Bethanie): Flats 4 km W of Goageb (–CD), *Van Zyl 3850* (NBG, WIND).

–2618 (Keetmanshoop): Flats on Gellap Ost, 19 ml from Keetmanshoop (–AC), *Liebenberg 5171* (PRE, WIND).

–2619 (Ardap): Farm Gross Aub: KEE 44 (–CA), *Giess 8366* (WIND); 3.6 m from Aroab on road to Koes (–DC), *De Winter 3460* (WIND).

–2718 (Grunau): Sandy slopes near Krai Kluft (–BA), *Pearson 7864* (BOL, PRE); Klein Karas (–CA), *Ortendahl 263* (PRE).

–2817 (Vioolsdrif): Gemsbokberg, 5 km from B1 on road to Ai-Ais (–BD), *Van Zyl 3828* (B, BOL, NBG, PRE, S, WIND); 22 Km N of Noordoewer on B2 (–DB), *Van Zyl 3758* (NBG, WIND).

–2818 (Warmbad): Limestone flats on farm Norachas: WAR 14 (–AA), *Giess, Volk & Bleissner 6902* (WIND); Sandy plains N of Ganus (–BA), *Pearson 4500* (BOL, K, PRE, Z); Quarts ridges on Witputz: WAR 258 (–CA), *Giess, Volk & Bleissner 6945* (WIND).

–3021 (Vanwyksvlei): Dolerite hill overlooking Vanwyksvlei (–BD), *Acocks 1747* (BOL, PRE).

7.12 **Zygophyllum retrofractum** *Thunb.*, Prodromus plantarum capensium 1 : 80 (1794); Pers.: 463 (1806); Thunb.: 545 (1823); Eckl. & Zeyh.: 96 (1835); Sond.: 364 (1860); Van Huysst.: 60 (1937); Schreib.: 98 (1963); A.Schreib. in Merxm.: 18 (1966). TYPE - Western Cape : Crescit in Carro infra Bockland *Thunb. sheet number 10130* (UPS-THUNB, holo!).

Zygophyllum microcarpum *Eckl. & Zeyh.*: 98 (1835) Type - Western Cape: In sabulosis (altit. I) ad fluvium Olifantsrivier (Clanwilliam) *Eckl. & Zeyh. 773* (C! lecto, designated here); *Eckl. & Zeyh. s.n.* (PRE 9885! and PRE 20934!).

Rounded, densely branched and many-stemmed shrub, reaching a height of 1.5 m and 2–4 m in diameter. *Stems:* old stems twisted, bark rimous, dark gray, usually with resprouting young shoots; young stems smooth, green, repeatedly branched and arched, without short shoots, round in cross section and without a ventral groove. *Leaves* opposite, petiolate, bifoliolate or alternate, sessile, opposite a branch; leaflets articulate, glaucous or green, suborbicular or obovate, flat or sometimes succulent and bulging, apex obtuse, base obtuse or cuneate, 2.0–4.5 (-7) x 1.5–3 mm; rachis apex triangular, membranous, reddish-brown; petiole articulate, oblong, fleshy, adaxially grooved, 2—5 mm long; stipules triangular, membranous, brown, margins often lacerate, two on ventral and two on dorsal side of stems, 0.5 x 0.5 mm, caducous. *Flowers* solitary or seldom two together, axillary. *Pedicel* 1—2 mm long. *Sepals* 5, oblong, articulate, some with membranous margins, outer ones slightly succulent, cucullate, 2 x 1 mm. *Petals* 5, spathulate, apex obtuse, sometimes undulate, base long-clawed, white, 2.5–4.0 x 0.5–1.0 mm. *Nectar disc* fleshy, smooth, prominently 10-lobed, lobes arranged in 5 pairs, each pair orientated upwards and outwards. *Stamens* 10, in two whorls; filaments terete, 3.5–4.5 mm long; staminal scales 10, alternately with different orientation, bipartite almost to the base, each segment oblong, apex rounded or obliquely lobed, margins entire, base asymmetrical, 1.5 x 0.5 mm, ± 1/2 the length of the filament. *Ovary* ovoid with tapering apex, 5-lobed, upper half globulate; style terete; stigma simple. *Fruit* an erect, septicidal schizocarp, variable in shape; subspheroid or ellipsoid, usually succulent when fresh, with visible sutures, when dry, 5-angled or 5-ribbed, ellipsoid or rhomboid with a dark and wrinkled exocarp, 3–5 x 3–5 mm, breaking up in 5 mericarps. *Seed* pyriform, 1—2 per locule, 2.0–2.5 x 1.0–1.5 mm, black, when immature attached by a long funicle, testa grainy, nearly transparent when wet and producing structured mucilage with short, spiral inclusions that seem to unravel at the apex (Figure 7.12.1).

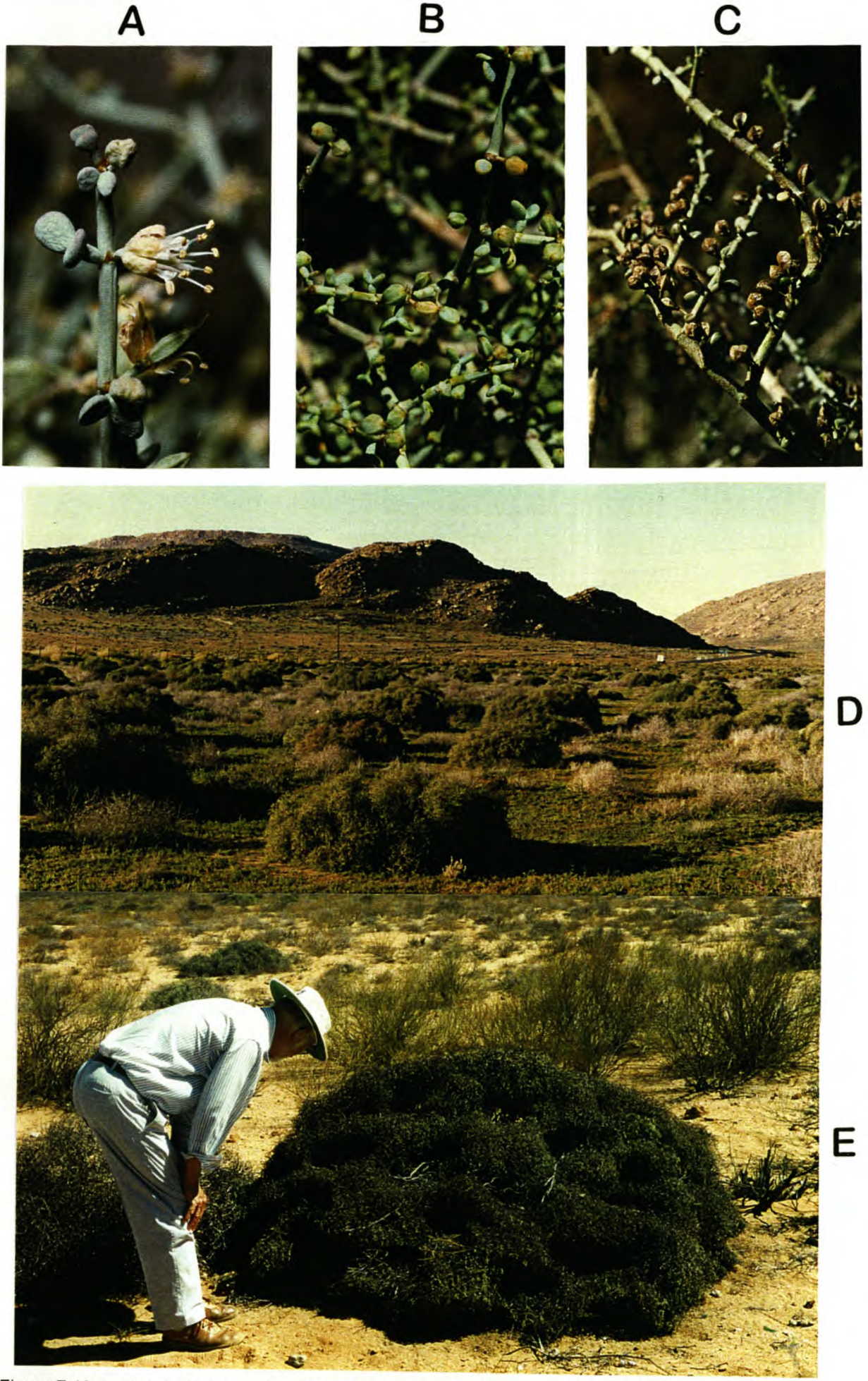


Figure 7.12.1. *Z. retrofractum*. A, twig with flower, young fruit, leaves and brown stipules, *Van Zyl 4541*; B, twigs with spherical, succulent fresh fruits, *Van Zyl 4541*; C, twigs with dry, ellipsoid or rhomboid, 5-angled or 5-ribbed fruits with a dark, wrinkled exocarp, *Van Zyl 4307*; D, habit along the N7 near Springbok, *Van Zyl 3821*; E, shrub with numerous rodent tunnels, *Van Zyl 4557*.

Diagnostic characters and affinities:

Z. retrofractum is distinguished by its large, 1.5 x 2.0–4.0 m size and dense, rounded shape which are often tunnelled by small rodents (Figure 7.12.1.D—E), by its repeatedly branched and arched stems (hence the specific epithet), by its succulent, small, suborbicular or obovate leaflets (Figure 7.12.1.A—C) and by its fruits which are usually succulent, subspheroid or ellipsoid with visible sutures when fresh and 5-angled or 5-ribbed, ellipsoid or rhomboid with a dark and wrinkled exocarp when dry and 3–5 x 3–5 mm in size (Figure 7.12.1.A—C). It is allied to *Z. chrysopteron* and *Z. turbinatum*. They all have small flowers with spathulate, white petals and small obovate, oblong or subrotund leaflets which represent the smallest leaves in § *Bipartita* with leaflet size ranging from 2.0–4.5 x 1.5–3.0 mm. Arching of stems is limited to these three species. The stems of *Z. retrofractum* show the deepest arches and those of *Z. chrysopteron* the shallowest ones. The colour of the stipules and the fruit shape can be used to differentiate between these species. The stipules of *Z. retrofractum* and *Z. chrysopteron* are brown and those of *Z. turbinatum* white. The fruits of *Z. retrofractum* are 5-angled and 5-ribbed but not winged, those of *Z. chrysopteron* spherical, golden-yellow and winged and those of *Z. turbinatum* turbinoid and winged. Table 7.3 summarizes the characters of the species in § *Bipartita*.

Distribution and ecology

Z. retrofractum occurs in the south-western parts of Namibia and is widespread along the west coast of South Africa and further inland (Figure 7.12.2). It is found from Helmeringhausen in the north (disregarding the single collection made at Ahub Mountain, hundreds of kilometers further north), in the Richtersveld and Namaqualand towards Vanrhynsdorp and further south with its range reaching the Ceres Karoo. A few outlyer populations occur at Augrabies in Bushmanland and in the Great Karoo near Williston and Frazerburg. More collections will probably fill up the gaps in this somewhat disjunct distribution pattern, because connecting vegetation types exist in which this species is known to occur. Within Namibia *Z. retrofractum* is found in vegetation classified as **Nama Karoo Biome** and **Succulent**

Karoo Biome (Irish 1994). Within South Africa it also occurs in these two Biomes, which is further refined as Upland Succulent Karoo, Lowland Succulent Karoo and Bushmanland Nama Karoo, Great Nama Karoo and Orange River Nama Karoo (Hoffman 1996). Both the Nama and Succulent Karoo Biomes occur on lime-rich but poor soils and they differ mainly in rainfall season. The Nama Karoo Biome receives rains during summer months whereas the Succulent Karoo Biome receives a low winter rainfall with extreme summer aridity.

Populations consist of scattered individuals over large areas. In the Garies area a single population stretched for about 20 kilometers along the N7. *Z. retrofractum* occurs on substrates of course, red sand or shale, on granite outcrops, on lime rich soils or along dry stream beds with thick, accumulations of silt. It is found on all aspects and gradients. A colour change from normal glaucous or green to bronze or copper indicates that water stress is experienced. *Z. retrofractum* is a drought deciduous plant and leafless shrubs is not uncommon. Grazing damage is rare probably because of its extremely bitter taste. However, small rodents often inhabit these shrubs or probably occupy the soil below it. Their presence is detected by the numerous tunnels through the shrubs (Figure 7.12.1.E) and their droppings on the ground. These rodents probably consume the mature, succulent fruits leaving immature fruits and leaves intact. Flowering period is from July to December, while fruits are found almost throughout the year. Possible pollinators are large and small black ants. Distribution and flowering data are incomplete because of the poor quality of herbarium specimens. Dried specimens are usually without leaves, flowers or fruits as they tend to fall off when dried and handled. These loose bits and pieces should be kept in sealed bags attached to the specimens for proper study and identification of specimens. Common names: jakkalsbos, vaalkareedoring.

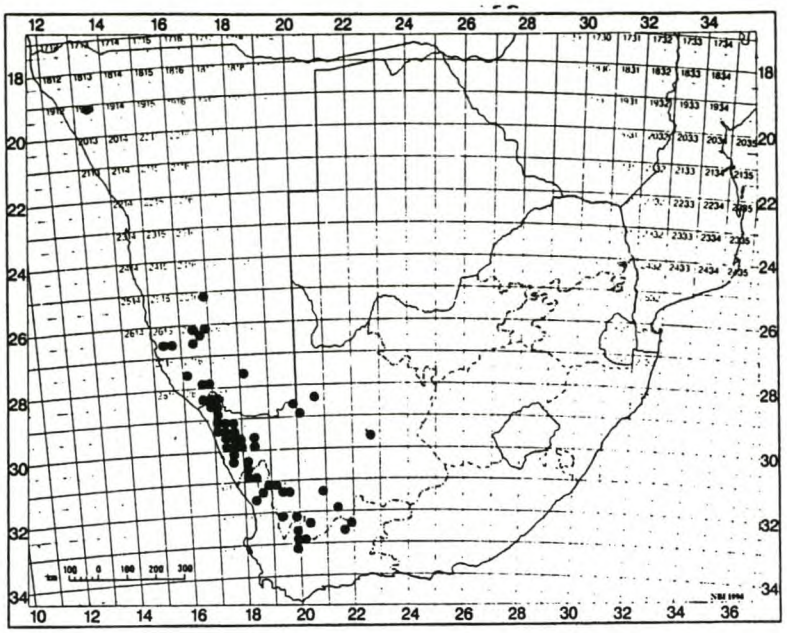


Figure 7.12.2. Geographical distribution of *Z. retrofractum.*

Material examined

–1913 (Sesfontein): Dry watercourse at Ahub Mountain (–AB), *Hardy & Venter 4563* (WIND).

–2516 (Helmeringhausen): Grootfontein: MAL 91 (–BB), *Volk 12868* (WIND); Near river on Grootfontein: MAL 91 (–BB), *Giess 10681* (PRE, WIND); Brackish flats on Kleinfontein Nord: MAL 82 (–BB), *Giess 8337* (WIND); E of Vorberge on Tsaukaib (–DA), *Wendt & Giess 15058* (WIND).

–2615 (Luderitz): Surface limestones at Haalenberg (–CB), *Giess 2375* (PRE, WIND); Lower slopes on E side of Tshaukaib (–DA), *Wendt in Giess 15058* (WIND).

–2616 (Aus): Tirasberge in district Bethanie (–AB), *Wiss 2407* (PRE, WIND); On farm Aris, W of Bethanie on road to Aus (–BC), *Germishuizen 8010* (PRE); Tirasberge in district Bethanie (–BB), *Merxmüller & Giess 2407* (PRE, WIND); On farm Aris, W of Bethanie on road to Aus (–BC), *Germishuizen 8010* (PRE); Commonage at Aus (–CB), *Van Zyl 3863* (NBG, WIND), *Dinter 6066* (BOL, NBG); Ridges N of house on farm Plateau (–CB), *Walter 2595* (WIND); 10 km W of Aus (–CB), *Dinter 3706* (NBG, PRE).

–2716 (Witputz): Watercourse at Aurus mountains (–CA), *Muller 748* (PRE, WIND); Sandy watercourse on farm Spitzkop: LU 111 (–DC), *Owen-Smith 1291* (WIND); Stony slopes on Zebrafontein: LU 87 (–DD), *Giess, Volk & Bleissner 5376a* (PRE, WIND); E side of farm Namuskluft: LU 88, Witputz area (–DD), *Giess, Volk & Bleissner 5356* (WIND); *Van Zyl 4391* (NBG).

–2718 (Grunau): Klein Karas (–CA), *Dinter 5106* (NBG, SAM).

–2816 (Oranjemund): Near Beesbank, NE of Oranjemund (–BC), *Van Zyl 4567* (NBG); Near the summit of Helskloof, Richtersveld (–BD), *Van Zyl 3921* (NBG); Grasvlakte turn off to Helskloof,

Richtersveld (–BD), *Van Zyl 3919* (NBG); Karagabkloof on Olienhoutplaas, Ploegberg, Richtersveld (–DB), *Oliver, Tölken & Venter 551* (PRE).

–2817 (Vioolsdrif): River banks at Kubus, Richtersveld (–AC), *Pillans 5426* (BOL); Gravel road W of Wildeperderant, Richtersveld (–CA), *Van Zyl 4571* (NG); W of Spitskloof, near Lekkersing, Richtersveld (–CC), *Van Zyl 4051* (B, NBG, S, WIND); W of Eksteensfontein, Richtersveld (–CC), *Van Zyl 4043* (NBG).

–2819 (Ariamsvlei): 44 M W of Augrabies at Schuitdrift (–DB), *Werger 162* (WIND).

–2820 (Kakamas): Lutzputs; Smalluis, roadside (–BC), *Gubb KMG 11110* (PRE); 40 km W of Kakamas (–CC), *Van Zyl 4314* (NG, PRE).

–2917 (Springbok): Near Vaalpan, E of Port Nolloth (–AA), *Van Zyl 4133* (NBG, PRE); S slopes of 15th Myl se Berg, near Gemsbokvlei (–AA), *Van Zyl 4574* (NBG); Near Rooidam se koppe, W of Steinkopf (–AB), *Van Zyl 4560* (NBG); Near Farquharson, W of Steinkopf (–AB), *Van Zyl 4561* (NBG); Sonsonderberg, SE of Port Nolloth (–AC), *Van Zyl 4083* (NBG); Kootjiesvlei, Namakwaland (–AD), *Leighton 2423* (BOL); Aninauspas, W of Steinkopf (–BA), *Van Zyl 3927* (NBG); Doornpoort, W of Steinkopf (–BC), *Compton 20636* (NBG); Noupoortsberg, W of Springbok (–CB), *Van Zyl 4085* (NBG, PRE); Kourootje farm, on way to Graafwater se Kop (–CD), *Le Roux & Lloyd 577* (NBG); Spektakelpas (–DA), *Meyer 7323* (PRE); Hester Malan Nature Reserve (–DB), *Rösch & Le Roux 181* (WIND); W of Springbok, next to N7 (–DB), *Van Zyl 3821* (NBG); Oubees se sand, NW of Kamieskroon (–DC), *Van Zyl 4089* (NBG); Droëdap, 22 km SE of Springbok (–DD), *Hilton-Taylor 2170* (NBG).

–2918 (Gamoep): On the road to Gamoep (–CB), *Ueckermann 7310* (PRE); Near Kourkamma se Holte, SE of Springbok (–CD), *Van Zyl 4087* (NBG).

–2922 (Prieska): Prieska (–DA), *Bryant s.n.* (PRE 45789).

–3017 (Hondeklipbaai): Boskloof, Kookfontein, 10 km NE of Soebatsfontein (–BA), *Hilton-Taylor 1300* (NBG); ± 4 km S of Soebatsfontein (–BA), *Van Zyl 4092* (NBG); Oubees, 9 km W of Springbok (–BA), *Le Roux & Lloyd 741* (NBG); Kookfontein, lower slopes of Deelkraal se berg (–BA), *Le Roux & Lloyd 768* (NBG); S of Buffelsrivier, N of Kamieskroon (–BB), *Van Zyl 4559* (NBG).

–3018 (Kamiesberg): Pella Refractory, Studors Pass, Garies (–AC), *Van Zyl 4105* (NBG, PRE); Modderfontein farm near Namaqua Wollastonite mine (–AC), *Van Zyl 4575* (NBG, PRE); Doornkraal road, E of Garies (–CA), *Van Zyl 4558* (NBG, PRE); Between Pramkop and Tafelkop, S of Garies (–CC), *Van Zyl 4576* (NBG, PRE); 24 km N of Bitterfontein (–CC), Van Zyl 4557 (NBG, PRE); Near Tweevlei, N of Bitterfontein (–CD), *Van Zyl 3747* (NBG, PRE).

–3118 (Vanrhynsdorp): Between Gemsbokvlei and Kalkgat Noord, Knersvlakte (–BB), *Van Zyl 4581* (NBG); Next to Doringrivier, Knersvlakte (–BB), *Van Zyl 4580* (NBG); Arizona, N of Vanrhynsdorp (–BC), *Van Zyl 4118* (NBG, PRE); Moedverloorrivier, ± 1 km after road forks to the N (–CB), *Van Blerk 15* (PRE); Moedverloorrivier (–CB), *Van Blerk 0015* (PRE); Liebendal, between Vredendal and Lutzville (–CB), *Van Zyl 3598* (NBG, PRE, S).

–3119 (Calvinia): Near Brandkop, ± 15 km N of Nieuwoudtville (–AA), *Van Zyl 4541* (BOL, NBG, PRE, WIND); Doringrivier banks, near Brandkop (–AA), *Van Zyl 4542* (NBG); Near Kareeboomkolk, N of Nieuwoudtville (–AA), *Van Zyl 4585* (NBG); Near Soetwater turn off, E of Nieuwoudtville (–AD), *Van*

Zyl 4543 (NBG); 20 km W of Calvinia on road to Nieuwoudtville (–BC), *Van Zyl 4032* (NBG); Near Agterplaas turn inn, 45 km E of Nieuwoudtville (–BC), *Van Zyl 4307* (NBG, PRE, S).

–3120 (Williston): Near the gate to Williston Stasie (–BD), *Smith 2451* (PRE).

–3121 (Frazerburg): Near Vondeling, on road to Frazerburg (–CD), *Van Zyl 3736* (NBG).

–3219 (Wuppertal): On way to Uitspanskraal from Dassiekloofpas (–AB), *Van Zyl 4218* (NBG); Gerustheid, Doringrivier (–AB), *Van Zyl 4213* (NBG); At homestead, Varschfontein, Tankwa Karoo National Park (–BB), *Theron 3907* (PRE); *Theron 3906* (PRE); 86 km S of Calvinia on road to Ceres (–DB), *Greuter 21797* (PRE); Bizantsgat, between Ceres and Sutherland (–DD), *Van Zyl 3740* (NBG); Skittery Camp Site, NE of Ceres (–DD), *Van Wyk 490* (NBG, PRE).

–3220 (Sutherland): Near Winternood at base of Oubergpas (–AD), *Van Zyl 4550* (NBG); Near Jukfontein, between Ceres and Sutherland (–CC), *Van Zyl 3739* (NBG, PRE).

–3221 (Merweville): Near Bulwater turn off between Leeu-Gamka and Frazerburg (–BD), *Van Zyl 3733* (NBG); Elim, N of Merweville (–DA), *Van Zyl 3730* (NBG).

–3319 (Worcester): ± 20 km N of Karoopoort on road to Calvinia (–BB), *Perry 1495* (NBG); Doringrivier crossing on Ceres to Sutherland road (–BB), *Van Zyl 4433* (NBG, PRE); *Van Zyl 4437* (NBG).

Without precise locality: *Dinter 1050* (SAM); *Esterhuysen 4006* (BOL); *Jordaan 68* (NBG); *Le Roux s.n.* (STE 24198 in NBG); *Levyns 1739, 1748* (BOL); *Range 423, 1288, 1661, 1611, 1734* (SAM); Poor quality specimen, not identifiable, Clanwilliam at the Olifants river, *Ecklon & Zeyher PRE 9885 and 20934* (PRE) detted as *Z. microcarpum*. In Fl. Cap this specimen is numbered E & Z 773.

Insufficiently understood specimens:

–2013 (Unjab Mouth): Sandy hummock at base of dunes at Koichab pump station (–BC), *Seely 2038* (WIND); 8 km E of Pumpstation at Koichabtal (–BC), *Merxmüller & Giess 28448* (WIND). These specimens are sterile but are possibly conspecific to *Z. retrofractum*.

7.13 **Zygophyllum chrysopteron** *Retief* in Bothalia: 21,1 : 55 (1991). TYPE - Northern Cape: 1 Km out of Vanwyksvlei, roadside, *Smook & Harding 782* (PRE, holo !).

Erect or rounded, woody shrub, branched from base, reaching a height of 0.7 m and a diameter of 1.5 m. *Stems:* old stems scarred, bark brown, slightly arched, sometimes displaying short shoots at nodes; short shoots densely scarred with remains of leaf bases and stipules, bearing a fascicle of leaves at apex; young stems smooth, green, repeatedly branched, slightly arched, round in cross section, without a ventral groove. *Leaves* opposite, petiolate, usually bifoliolate but regularly and alternately only developed to a simple, sessile state along the stems; leaflets

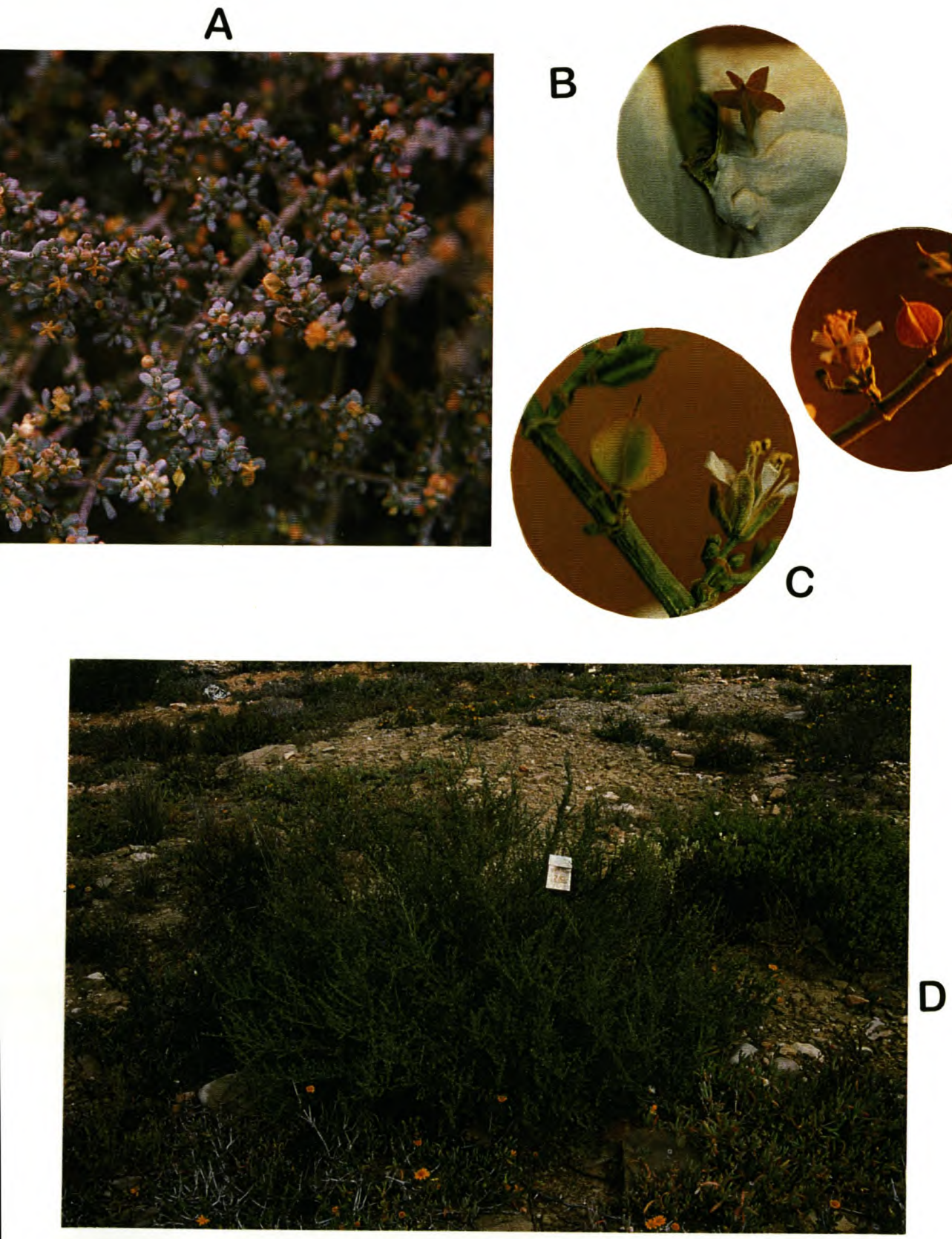


Figure 7.13.1. *Z. chrysopteron, Van Zyl 4517*. A, leafy branch with golden-yellow, 5-winged fruits; B, top-view of 5-winged fruit; C, twigs with flower and side-view of subspherical fruit; D, habit along the Klaarstroom - Prins Albert road.

articulate, glaucous or green, oblong or obovate, apex and base obtuse, flat or often succulent and bulging, 2.0–2.5 x 1.5–2.0 mm; rachis apex triangular, membranous, brown; petiole articulate, oblong, fleshy, adaxially grooved, 2.0–2.5 mm long; stipules triangular, membranous, brownish, margins often lacerate, two on ventral and two on dorsal side of stem, 0.5 x 0.5 mm, caducous. *Flowers* solitary or rarely two together, axillary. *Pedicel* 1—2 mm long. *Sepals* 5, oblong, membranous margined, outer ones slightly succulent, cucullate, 2 x 1 mm. *Petals* 5, spathulate, apex obtuse, base long-clawed, white, 3.0–4.0 x 0.5–1.0 mm. *Nectar disc* fleshy, smooth, prominently 10-lobed, lobes arranged in 5 pairs, each pair orientated upwards and outwards. *Stamens* 10; filaments terete, 3.5—4 mm long; staminal scales 10, alternately with different orientation, bipartite almost to base, each segment oblong, apex rounded or obliquely lobed, base asymmetrical, margins entire, 1.5–1.8 x 0.4–0.5 mm, ± 1/2 the length of the filament. *Ovary* ovoid, 5-parted, with tapering apex, globulate; style terete; stigma simple. *Fruit* an erect, golden-yellow, subspherical, 5-winged, septicidal schizocarp, 3.0–4.0 x 3.5–4.0 mm, breaking up in 5 mericarps, wings usually thin and reticulate-veined, but sometimes slightly thicker and rib-like. *Seed* pyriform, 1–2 per locule, 2.0 x 1.5 mm, nearly black, when immature attached by a long funicle, testa grainy, when wet becoming transparent and producing structured mucilage with short, spiral inclusions that seem to unravel at the apex (Figure 7.13.2).

Diagnostic characters and affinities:

Z. chrysopteron is recognized by its erect, sub-spherical, 5-winged fruits with thin reticulate-veined wings (Figure7.13.1.A–C) which usually are thicker and more rib-like towards the western range of its distribution, by the golden-yellow mature fruits (hence the specific epithet) present in abundance on stems, by its repeatedly, shallowly arched stems and by its small, obovate or oblong, succulent leaflets. It is allied to *Z. retrofractum* and *Z. turbinatum* with regard to floral, stem and leaf morphology. These three species display arched stems, not found in other species of *Zygophyllum*. The branches of *Z. retrofractum* are prominently arched (Figure 7.12.1.D) whereas in *Z. chrysopteron* they are less prominently arched (Figure7.13.1.D). These three species have the smallest leaves in § *Bipartita*, with

leaflet size ranging from 2.0–4.5 x 1.5–3.0 mm. They are distinguished by their different fruits. The fruits of *Z. chrysopteron* are as described above, the fruits of *Z. turbinatum* are turbinoid and widely 5-winged, the fruits of *Z. retrofractum* are succulent and spheroid when mature and still fresh, and when dry, become ellipsoid or rhomboid, 5-angled or 5-ribbed with a dark, wrinkled exocarp. Table 7.3 summarizes the characters of the species in § *Bipartita*.

Distribution and ecology

Z. chrysopteron is widespread in the interior of South Africa (Figure 7.13.2). It occurs in the Bushmanland area and in the Great Karoo and its range stretches from the Knersvlakte in the west, through the Ceres Karoo and Klein Karoo to as far east as Steytlerville. A single collection made south of Karasburg, in the **Nama Karoo Biome** (Irish 1994), represents this species in Namibia. In South Africa it occurs in vegetation classified as **Nama Karoo Biome**: Bushmanland Nama Karoo, Upper Nama Karoo, Orange River Nama Karoo, Great Nama Karoo and Central Lower Nama Karoo (Hoffman 1996); **Succulent Karoo Biome**: Lowland Succulent Karoo, Upland Succulent Karoo and Little Succulent Karoo (Hoffman 1996). In the Nama Karoo the dominant plants are grasses and small shrubs which become deciduous in response to rainfall events. Rainfall occurs during the summer months. In the Succulent Karoo the vegetation is dominated by dwarf, succulent shrubs and rainfall occurs during winter months with extreme summer aridity. *Z. chrysopteron* is well adapted to both these biomes by having succulent leaves and by its ability to repeatedly shed and resprout leaves in response to climatic conditions. Populations of *Z. chrysopteron* consist of scattered individuals over large areas. It can be assumed that this species is palatable, because grazing damage is usually severe with the result that undamaged individuals of this species are sometimes found only in inaccessible spots. On the Knersvlakte, where it occurs together with *Z. retrofractum*, this species is heavily grazed in contrast to *Z. retrofractum,* which is not. Flowering period is from September to December and fruits are found almost throughout the year. Although fruiting specimens, collected during the flowering period, usually have an abundance of fruits in which the dark seeds are clearly

visible, mature fruits with ripe seeds are rarely found. Bees and ants are active on flowering shrubs of *Z. chrysopteron* and probably serve as pollinators. Distribution and flowering data for this species are incomplete because of the poor quality of the dried specimens studied. Herbarium specimens are often without leaves, flowers or fruits as they tend to fall off when dried and handled. These loose bits and pieces should be kept in sealed bags attached to the sheets for proper study and identification of the specimens.

Common name: Kleinskilpadbos.

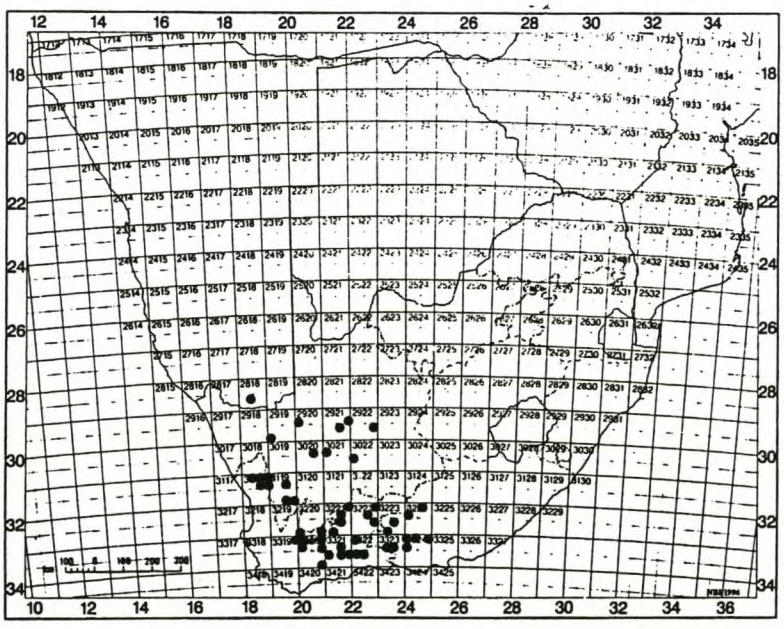


Figure 7.13.2. Geographical distribution of *Z. chrysopteron*.

Material examined

–2818 (Warmbad): River bed at Dabaigabis, S of Karasburg (–CB), *Pearson 4317* (BOL).

–2919 (Pofadder): Bosluis se Pan, W of Kleinputs (–CC), *Perold 2071* (PRE).

–2920 (Boomrivier): 5 M W of Loogkolk (–AC), *Pole-Evans 2244* (PRE).

–2921 (Kenhardt): Red sand on Jacomynspan (–BD), *Cole & Catt 212* (PRE); Jagbult, 40 M W of Marydale (–DA), *Story 1108* (PRE).

–2922 (Prieska): Hard Kalkveld, Karabee, district Prieska (–DB), *Roux 131* (PRE).

–3020 (Brandvlei): NW of gate near farmhouse on Rietkolk, Bushmanland (–BC), *Le Roux & Lloyd 230* (PRE).

–3022 (Carnarvon): Dolerite ridge at Rhenosterkolk, Carnarvon (–CA), *Acocks 1719* (PRE), *Botha 2999* (PRE).

–3118 (Vanrhynsdorp): N of Rooiberg next to N7, Nuwerus district (–AB), *Van Zyl 4577* (NBG, PRE); Near Uitspanning, Knersvlakte (–BA), *Van Zyl 4578* (NBG, PRE); At Gemsbokrivier, Knersvlakte (–BB), *Van Zyl 4583* (NBG); Dry river bed of Doringrivier, Knersvlakte (–BB), *Van Zyl 4579* (NBG); Near Kliprand turn off from N7 (–BC), *Van Zyl 4556* (NBG); Near Arizona, N of Vanrhynsdorp (–BC), *Van Zyl 4555* (NBG, PRE); Near Vierfontein, base of Vanrhynspas (–BD), *Van Zyl 4586* (NBG, PRE); Near Grootdrif, NE of Vanrhynsdorp (–BD), *Van Zyl 4540* (NBG, PRE).

–3119 (Calvinia): Near Matjiesfontein, next to R27, Nieuwoudtville (–BC), *Van Zyl 4544* (NBG, PRE); S slopes of Bloukranspas, Calvinia (–DC), *Van Zyl 4545* (NBG, PRE); At Dassieberg, S of Calvinia (–DD), *Van Zyl 4548* (NBG, PRE); Between Middeldrif and Dassieberg, S of Calvinia (–DD), *Van Zyl 4546* (NBG).

–3220 (Sutherland): Muishondrivier, Ceres district (–CC), *Esterhuysen 1859* (BOL); Near Kareedoornkraal, S of Sutherland (–DD), *Van Zyl 4551* (BOL, NBG, PRE, S).

–3221 (Merweville): River banks on Layton farm, Beaufort West (–BB), *Shearing 382* (PRE); Near Bulwater turn off (–BC), *Van Zyl 3732* (NBG); Flats, near Middelkop (–CD), *Van Zyl 3725* (NBG); Flats on Elim, N of Merweville (–DA), *Van Zyl 3729* (NBG).

–3222 (Beaufort West): Courlands Kloof, Nelspoort (–BB), *Pearson 2018* (SAM); At Beaufort West (–BC), *Adamson D155* (PRE); *Thode STE 4843* (NBG); N part of Mimosa Golf course at Beaufort West (–BC), *Van Zyl 4163* (NBG); Oude Volkskraal, SE of Beaufort West (–BC), *Van Zyl 4165, 4165a* (NBG); Hoenderverdriet, 37 km SE of Beaufort West (–DB), *Van Zyl 4167* (NBG); Near Neverset , SE of Beaufort West (–DB*), Van Zyl 4169* (NBG).

–3223 (Rietbron): Along Bosduiwerivier on Kalkdam, Beaufort West (–CD), *Retief & Reid 349* (PRE); Near Karigarivier on Beaufort West to Aberdeen road (–DA*), Van Zyl 4170* (BOL, NBG, S).

–3224 (Graaf-Reinet): SW of Aberdeen (–CA), *Maguire 740* (NBG); On limestone ridges 2 M N of Graaf-Reinet (–BA), *Bolus BOL 652* (BOL).

–3319 (Worcester): Doringrivier crossing with Ceres-Sutherland road (–BB), *Van Zyl 4434* (NBG).

–3320 (Montagu): Near Perdekraal on gravel road between Matjiesfontein and Ceres (–AA), *Van Zyl 4154* (NBG); Avondrus farm, 30 km SE of Touwsrivier (–AC), *Hilton-Taylor 1977* (NBG); Viskuil farm,

Laingsburg (–BB), *Kotze 148* (NBG); Springboklaagte, NE of Laingsburg (–BB), *Van Zyl 4553* (NBG); Top of Suikerdrifkloof near Ou Tol (–BD), *Van Zyl 3716* (NBG); In clay hills between Kochmanskloof and Gauritzrivier (–CC/CD), *Ecklon & Zeyher 772* (S, TCD); 18 km W of Ladismith on road to Barrydale (–DD); *Mauve, Reid & Wikner 184* (NBG); 30 km E of Barrydale (–DD), *Van Zyl 3688* (NBG).

–3321 (Ladismith): Flats near Gamkaspoortdam (–BC), *Van Zyl 3701* (NBG); At turn off to Grootrivier and Kerkplaas, W of Ladismith (–CA), *Van Zyl 3703* (NBG); Near Grootrivier bridge, W of Ladismith (–CA), *Van Zyl 3706* (NBG); Buffelsdrif, W of Ladismith (–CA), *Laidler 304* (NBG); Rietvleirivier Valley, SW of Calitzdorp (–DA), *Oliver 5284* (NBG); Gannavlakte, E of Calitsdorp (–DA), *Van Zyl 3945* (BOL, NBG, S); Near Volmoed turn off on Calitsdorp-Oudshoorn road (–DB), *Van Zyl 4191* (NBG, PRE).

–3322 (Oudshoorn): 20 km E of Prins Albert on road to Klaarstroom (–AC), *Van Zyl 4517* (NBG); Flats, 6 km W of Oudshoorn (–CA), *Van Zyl 3648* (NBG); 3 km SE of Lategansvlei (–CA), *Hilton-Taylor 838* (NG); 8 km from Oudshoorn on road to De Rust (–CB), *Van Zyl 4523* (NBG).

–3323 (Willowmore): Ghwarriepoort, ± 10 km SW of Willowmore (–AD), *Van Zyl 4189* (NBG); Bosnek, near Skerpkop Stasie (–BC), *Hilton-Taylor 547* (NBG).

–3324 (Steytlerville): Near Heuningklip, N of Steytlerville (–AA), *Van Zyl 4185* (NBG); Between Goedehoop and De Poort, N of Steytlerville (–AB), *Van Zyl 4182* (NBG); Hopedale, Steytlerville (–AC), *Hilton-Taylor 504* (NBG); Between farm house and main road on Nashville, Steytlerville (–AC), *Hilton-Taylor 444* (NBG); Slangfontein, Klipplaat (–BB), *Hoffman 720* (GRA).

Ecklon & Zeyher 772 misidentified as *Z. horridum* sensu Eckl. & Zeyh. is included under 3320 (–CC/CD).

7.14 **Zygophyllum turbinatum** *Van Zyl*, sp. nov. (§ *Bipartita), Z. chrysopteroni* affinis sed habitu effuso (non erecto), caulis repetite ramosis arcuatis (non aliquando rectis, non prominenter arcuatis), surculis juventis apicalibus paene glabris, aphyllis, capsula alata, turbinata (alata sed in circumscriptione subglobularis) differt. TYPE - Western Cape: 20 Km E of Prins Albert on Klaarstroom road, *Van Zyl 4516* (NBG, holo., B, BOL, K, PRE).

Rounded shrub, densely branched from a woody base, reaching a height of 0.6 m and a diameter of 1.0 m. *Stems:* old stems nude, rough, bark finely cracked, dark gray, repeatedly branched and arched and displaying short shoots of up to 1 cm long on the older parts of its lower stems; short shoots densely scarred with remains of leaf bases and stipules, often leafless or with a fascicle of leaves at apex; young stems leafy, smooth, gray, repeatedly branched and arched, without short shoots;

newest growth pale fawn or cream coloured, branched and arched in the same way but usually nude or with minute, not fully developed leaves, round in cross section and without grooves. *Leaves* opposite, petiolate, bifoliolate; leaflets articulate, glaucous or tinted pink, narrowly obovate or oblong, often immature and only developed to unifoliolate or sessile state, succulent, apex obtuse or mucronate when very young but hardly so when mature and succulent, base obtuse, 3–4 x 1.5 mm; rachis apex filamentous, minute; petiole articulate, oblong, fleshy, adaxially grooved, 3—6 mm long; stipules triangular, membranous, white, margins lacerate, two on ventral and two on dorsal side of stems, 0.5 x 0.5 mm, caducous. *Flowers* solitary, axillary. *Pedicel* 1—2 mm long. *Sepals* 5, articulate, oblong, membranous margined, outer ones slightly succulent and cucullate, 2–3 x 1–2 mm. *Petals* 5, spathulate, apex obtuse, base long-clawed, white, 3–4 x 1.0–1.5 mm. *Nectar disc* fleshy, smooth, prominently 10-lobed, lobes arranged in 5 pairs, each pair orientated upwards and outwards. *Stamens* 10; filaments terete, 4.0—4.5 mm long, anthers reddish-brown, pollen light yellow; staminal scales 10, alternately with different orientation, bipartite almost to base, each segment oblong, apex rounded or obliquely lobed, margins entire, base asymmetrical, 1.8 x 0.5–0.8 mm, ± ½ the length of the filament. *Ovary* obovoid with tapering apex, 5-lobed, upper half globulate; style terete; stigma simple. *Fruit* an erect, turbinoid, 5-winged, septicidal schizocarp, 4–5 x 4–5 mm in size, wings membranous, sometimes undulate, tinted pink, breaking up in 5 mericarps. *Seed* pyriform, 1–2 per locule, 2.5 x 1.5 mm, dark, when immature attached with a long funicle; testa grainy, when wet becoming nearly transparent and producing a thick layer of structured mucilage with short, spiral inclusions that seem to unravel at apex (Figure 7.14.1—2).

Diagnostic characters and affinities:

Z. turbinatum is recognized by its erect, turbinoid (hence the specific epithet), 5-winged fruits with pink tints (Figure 7.14.2.A—B) which are found in abundance on shrubs, by its repeatedly arched stems Figure 7.14.2.D), by the brachyblasts or short shoots usually present on older stems (Figure 7.14.1.B) and by its small petiolate, bifoliolate leaves which have narrowly obovoid or oblong, succulent leaflets, 3–4 x 1.5 mm in size (Figure 7.14.2.A—B). It is allied to *Z. retrofractum* and *Z.*

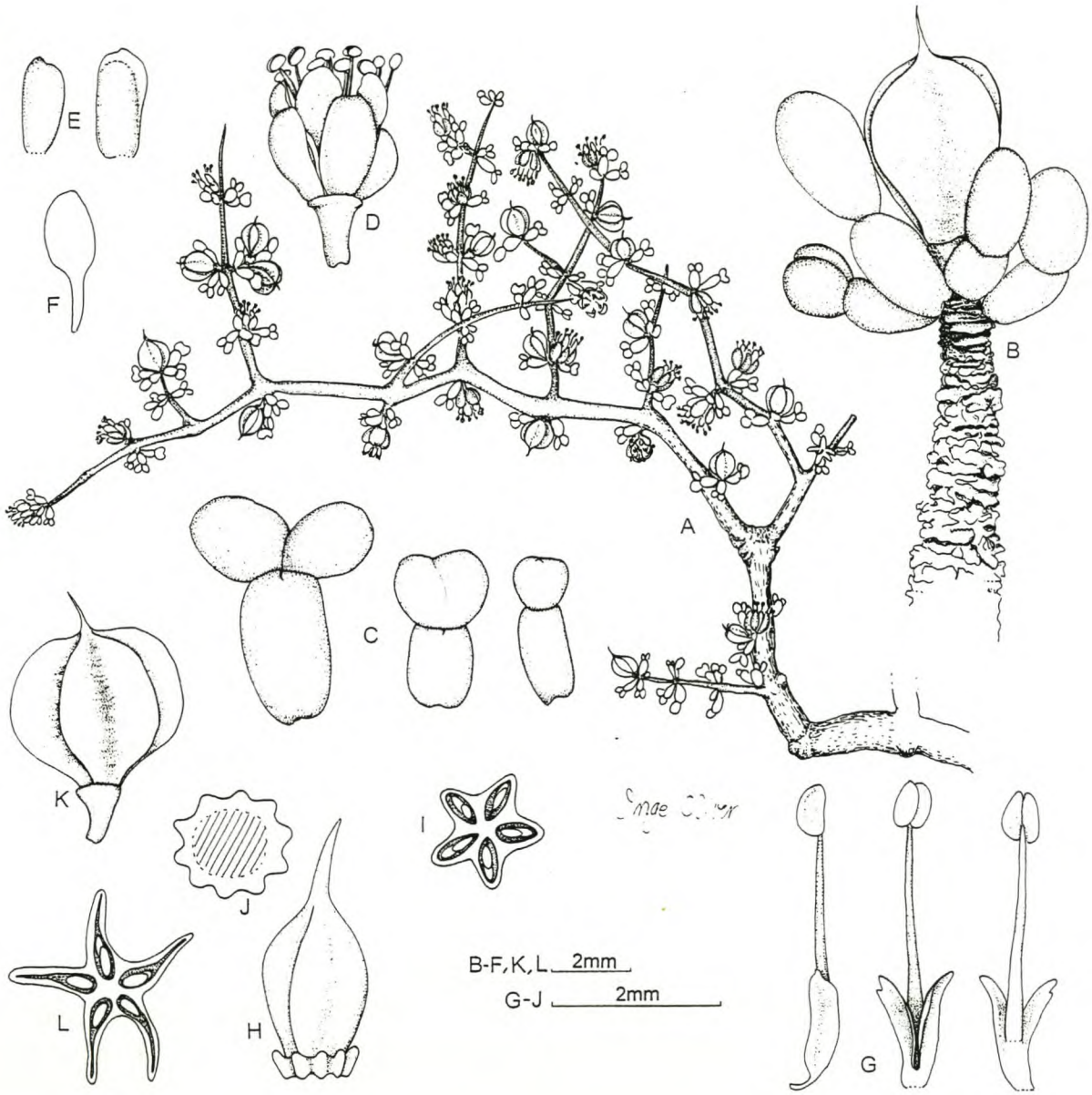


Figure 7.14.1. *Z. turbinatum, Van Zyl 4516*. A, flowering and fruiting branch, life-size; B, short shoot with a fascicle of leaves and an immature fruit at apex; C, range of leaves; D, side-view of flower; E, sepals; F, petal; G; side-view, ventral-view and dorsal-view of staminal scales; H, ovary; I, cross section of ovary; J, cross section of nectar disc; K, side-view of mature fruit; L, cross section of mature fruit.

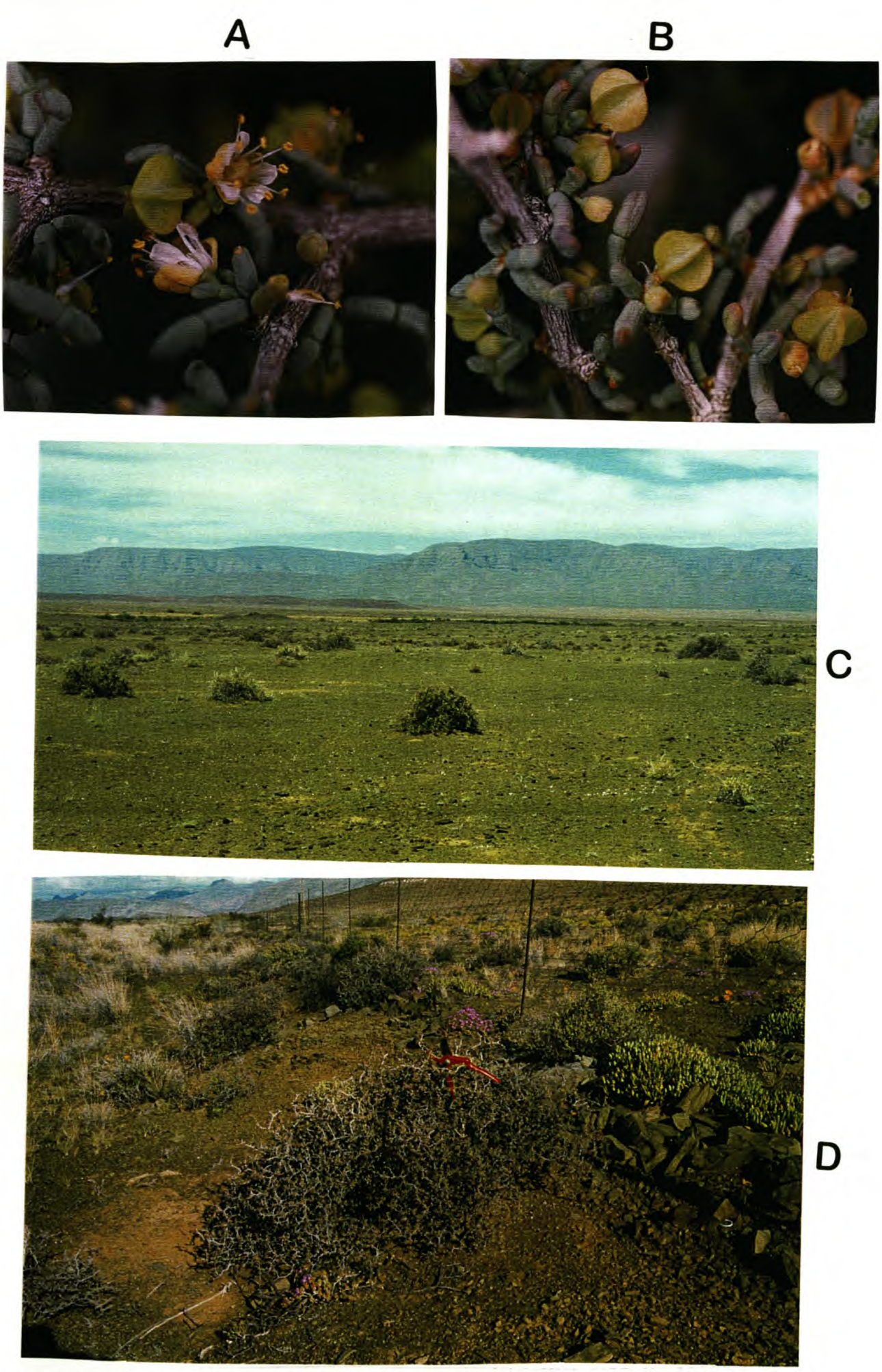


Figure 7.14.2. *Z. turbinatum*. A—B, twigs with leaves, flowers and fruit, *Van Zyl 4516*; C, habitat on the Springbokvlakte, *Van Zyl 4549*; D, habit E of Prins Albert, displaying a topping of pale coloured, nude, young growth, *Van Zyl 4516*.

chrysopteron with regard to floral and leaf morphology and these three species display similar, repeatedly arched stems. The stems of *Z. retrofractum* are most prominently arched and those of *Z. chrysopteron* the least so. These three species have the smallest leaves in § *Bipartita* with leaflets ranging from 2.0–4.5 x 1.5–3.0 mm in size. The white stipules of *Z. turbinatum* are diagnostic, whereas the stipules of both *Z. retrofractum* and *Z. chrysopteron* are brown. These three species differ with regard to fruit morphology. The fruits of *Z. turbinatum* are as described above, those of *Z. chrysopteron* are spherical, 5-winged and golden-yellow (Figure 7.13.1.B—C) and those of *Z. retrofractum* are spheroid and succulent when mature and still fresh, and when dry become ellipsoid or rhomboid, 5-angled or 5-ribbed with a dark, wrinkled exocarp (Figure 7.12.1.B—C). Table 7.3 summarizes the characters of the species in § *Bipartita*.

Distribution and ecology

Z. turbinatum is found in the interior of South Africa, in the Great and Little Karoo as well as in the Ceres and Tanqua Karoo (Figure 7.14.3). It occurs in vegetation classified as **Succulent Karoo Biome**: Lowland Succulent Karoo and Little Succulent Karoo (Hoffman 1996), both of which are extremely arid vegetation types in which Mesembryanthemaceae dominates. Rainfall occurs during winter and summers are hot and dry. The main distribution is in the Great Karoo around Beaufort West and Laingsburg in vegetation classified as **Nama Karoo Biome**: Great Nama Karoo which is dominated by dwarf shrubs (Hoffman 1996). Rainfall occurs during autumn and winter and towards the eastern part of the range the precipitation also occurs throughout the year. Most populations are large and consist of scattered individuals over large areas usually including many young plants. On some stretches of the Tanqua Karoo, *Z. turbinatum* was the only plant species seen at all. It thrives on pebbly, greenish silt, on shale, dolerite and loam, mostly on flat valley floors or on low hills. In the sparse Karoo vegetation in which it is usually found, these shrubs can be prominent because of the topping of pale fawn or cream-coloured, nude, new growth, or because of the bare, gray older stems, which become visible when denuded of leaves by grazers. Severe grazing damage is common. Flowering period is from September to November. Some fruits remain

attached to plants for several months during which time they mature. The mericarps are dispersed as a unit containing the seeds. Distribution is probably by wind. Because of the large size of some populations and because grazers can only consume the younger and softer parts of these hardy shrubs, this species is probably not threatened at present.

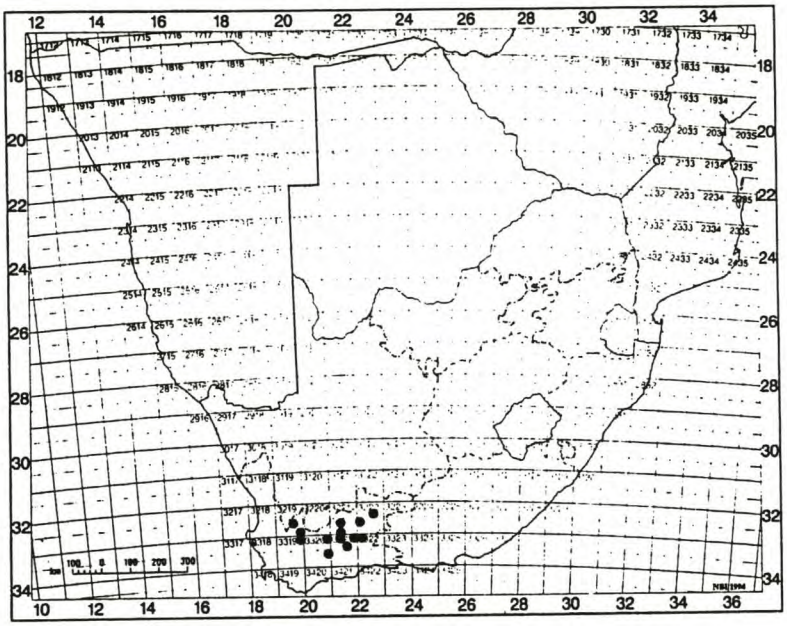


Figure 7.14.3. Geographical distribution of *Z. turbinatum*.

Specimens examined

–3219 *(Wuppertal):* Grootdam farm on Ceres to Calvinia road, 20 km N of Katbakkies (–DA), *Hilton-Taylor 1638* (NBG); Near Droëkloof and Kalkgat turn off, S of Bizantsgat (–DD), *Van Zyl 3741* (NBG).

–3220 (Sutherland): Platfontein, near Gebe, Springbokvlakte (–AC), *Van Zyl 4549* (B, BOL, NBG, PRE, S).

–3221 (Merweville): Near Fonteinskop, Laingsburg district (–CB), *Van Zyl 3727a* (NBG), 3726 (NBG, PRE); Between Kogelfontein and Geelpoort se Nek, NE of Laingsburg (–CD), *Van Zyl 3724* (NBG, PRE); Near Middelkop (–CD), Van Zyl 3725a (NBG).

–3222 (Beaufort West): N part of Mimosa Golf Course at Beaufort West (–BC), *Van Zyl 4164* (B, BOL, NBG, PRE); ± 65 km S of Beaufort West on N1 (–CA), *Van Zyl 4161* (NBG, PRE); Wolwehoek (–CA), *Shearing 560* (PRE).

–3319 (Worcester): Near Doringrivier crossing with Ceres to Sutherland road (–BB), *Van Zyl* 3743 (NBG).

–3320 (Montagu): 1 km N of Laingsburg, on Moordenaarskaroo road (–BB), *Van Zyl 3718* (NBG); Near Buffelsrivier farm, NE of Laingsburg (–BB), *Van Zyl 4554* (B, BOL, NBG, PRE, S); 41 km E of Barrydale, near bridge over Bosvlakte river (–DB*), Van Zyl 3689* (NBG).
–3321 (Ladismith): Between Ketting and Gemsbok Stasies, NE of Laingsburg (–AB), *Van Zyl 4159* (B, K, NBG, PRE, S); Botterkraal, Prins Albert district (–BB), *Bolus s.n.* (BOL 49139); Gamkapoort Nature Reserve, at crossing of Bosluiskloof river (–BC), *Laidler 604* (NBG).
–3322 (Oudshoorn): 20 km E of Prins Albert on Klaarstroom road (–AA), *Van Zyl 4516* (B, BOL, K, NBG, PRE).

7.15 **Zygophyllum decumbens** *Del.* var. **decumbens** Delile Illust. Fl. Egypte 221 t. 27, f. 3 (1813); DC.: 705 (1824); Huysst.: 60 (1937); El Hadidi in Tackholm: 311 (1974); El Hadidi: 62 (1978); El Hadidi: 439 (1978a); El Hadidi: 335 (1980). TYPE - Valleé dans l'Egaroment, *Delile s.n.* (MPT, FI). n.v.

Note: I could not find the type of this species, neither the original publication which probably includes an illustration. A very poor excuse is the fact that I concentrated on the southern African species and at the time of writing up this thesis, time was too short to rectify this. Before any publication including *Z. decumbens* this will be rectified!
Hosny (1977) described a new variety of this species, *Z. decumbens* Del. var *megacarpum* from Egypt. El Hadidi (1980) considered the southern African *Z. decumbens* as well as its synonyms *Z. dregeanum* Sond., *Z. densiflorum* Schinz. and *Z. maximiliani* Schltr. ex Huysst. as conspecific with the new variety. I managed to see and photograph a specimen of this new variety, annotated by Hosny, *Schweinfurt 2238* (K!). When comparing the fruits of southern African material with those on the photograph, I noticed a big difference and therefore must disagree with El Hadidi's (1980) decision until seeing both the type of the typical species and its variety. I am using the name *Z. decumbens* Del. var. *decumbens* throughout this thesis.

Zygophyllum densiflorum *Schinz: Schinz:* 181(1890); *Huysst.: 59 (1937); A. Schreib.: 80 (1963)* Tsaus, S of Aus, Gross Namaland, *Schenck 205* (Z!).

Zygophyllum dregeanum *Sond.*: 365 (1860); Schlechter & Diels in Schultze: 705 (1907); Huysst.: 59 (1937); A.Schreib.: 80 (1963); A.Schreib. in Merxm. 15 (1966). TYPE - Western Cape: Mountain at Trado, 2000f., Drège 7164 (error)(S!, Drège 7174, holo., annotated by Sonder).

Zygophyllum maximiliani *Schltr. ex Huysst.*: 60 (1937). TYPE - Namibia: Henkries, Bushmannland, Max Schlechter 11 (Z!, lecto, designated here, K, PR, S!).

Shrub with spreading, plumose branches, radiating from a woody base, reaching a height of 0.7 m and a diameter of 1.0 m, young parts densely glandular. *Stems:* old stems smooth, brownish-gray, sometimes with pink tints, nodes swollen; young stems smooth, ivory coloured, stem tips green, round in cross section, with a ventral groove. *Leaves* opposite, bifoliolate, petiolate, on flowering branches gradually reduced to a simple, sessile state; leaflets articulate, glaucous or green, secund, obliquely subrotund or widely obovate, apex rounded, base obtuse or cuneate, 7–17 x 6–11 mm; rachis apex filamentous, minute; petiole articulate, oblong, adaxially grooved, 5—9 mm long; stipules narrowly triangular, membranous, margins lacerate, white or translucent, two on ventral and two on dorsal side of stems, 2.0 x 0.5 mm, caducous. *Inflorescence* arranged in a cyme. *Pedicel* 3—7 mm long. *Sepals* 5, oblong, membranous margined, outer ones slightly succulent, cucullate, 2.0–3.0 x 1.5 mm. *Petals* 5, obovate, apex obtuse, base with a long claw, white or cream, sometimes drying to light orange or salmon colour, 4.0–5.0 x 0.8–1.5 mm. *Nectar disc* fleshy, smooth, 10-angled, with ten small lobes orientated downwards on its sides, the disc as a whole sloping slightly towards its periphery. *Stamens* 10; filaments terete, 5.5—6.0 mm long; staminal scales 10, alternately differently orientated, bipartite almost to base, each segment oblong or ovate, apex obtuse or acute or obliquely lobed, margins entire, base asymmetrical, 2.0 x 0.5 mm, ± 1/3 the length of the filament. *Ovary* ovoid or ellipsoid, 5-parted, globulate; style terete; stigma simple. *Fruit* an erect, 5-parted, rhomboid or turbinoid, septicidal schizocarp, 3.0–4.0 x 3.0–4.5 mm in size; breaking up in 5, spongy mericarps. *Seed* pyriform, 8—10 per locule, 1.0 x 0.5 mm, light brown, when immature attached by a long funicle, testa grany, nearly transparent when wet and producing structured mucilage with short, spiral inclusions that seem to unravel at the apex (Figure 7.15.1).

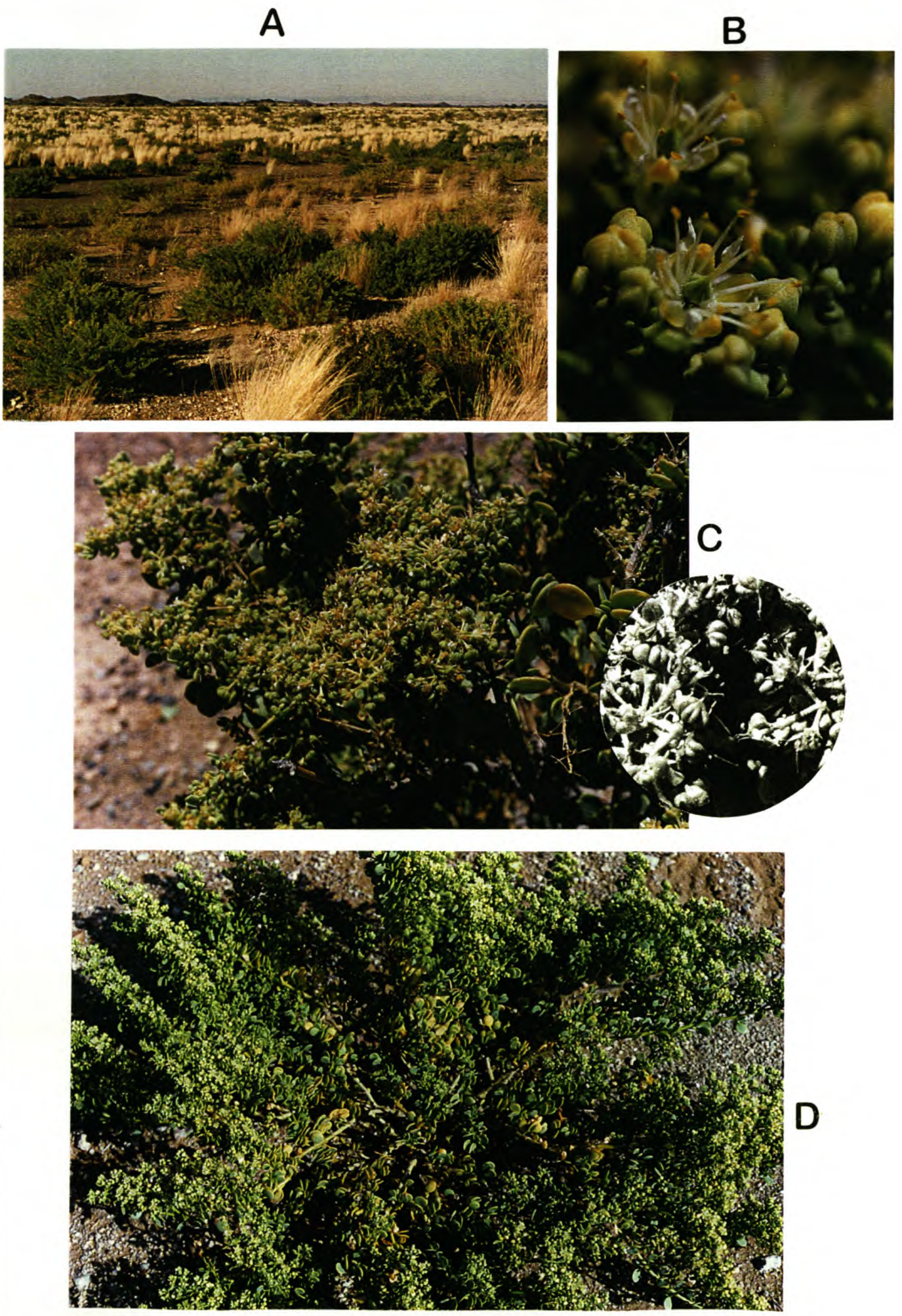


Figure 7.15.1. *Z. decumbens* var. *decumbens*. A, habitat near Keetmanshoop, *Van Zyl 3770*; B, twig with buds and open flowers, *Van Zyl 4317*; C, fruiting branch, including an enlargement of some fruits, *Van Zyl 4317*; D, habit near Pella, *Van Zyl 4317*.

Diagnostic characters and affinities:

Z. decumbens is distinguished by its radiating, plumose branches which end in a dense, cymose inflorescence (Figure 7.15.1.C—D) and by the presence of dense, glandular trichomes on all its young parts. The cymose inflorescence and glandular trichomes both are rare characters in the § *Bipartita. A*ll other members of this section have 1 or 2, axillary flowers and lack glandular trichomes. *Z. decumbens* var. *decumbens* is also distinguished by its fruits which are 5-parted, rhomboid or ellipsoid and which break up in 5 spongy mericarps (Figure 7.15.1.C). The spongy mericarps resemble those *of Z. clavatum* when seen from above, but differ in side view, those of *Z. decumbens* var. *decumbens* are rhombic or elliptic, those of. *Z clavatum* are depressed ovoid. The obliquely subrotund or widely obovate leaflets of *Z. decumbens* var. *decumbens* resemble those of *Z. clavatum* and *Z. applanatum* but are larger. They range in size from 7–17 x 6–1 mm, those of *Z. clavatum* from 4.0–9.0 x 2.0–4.5 mm and those of *Z. applanatum* from 4–7 x 4–7 mm. Although there is no doubt about its inclusion in § *Bipartita*, it has no close allies and stands somewhat on its own within the section.

Distribution and ecology

Z. decumbens is widespread in the southern half of Namibia (Figure 7.15.2). Its range extends into the Bushmanland area in the Northern Cape Province of South Africa. In Namibia it is found in a vegetation classified as the **Nama Karoo Biome** (Irish 1994) and in the Northern Cape Province also in **Nama Karoo Biome**: Orange River Nama Karoo (Hoffman 1996). In these areas rains usually occur during summer but towards the west of the area, may occur during late autumn. Populations are large and consist of many individuals of all sizes and ages dispersed over large areas. No grazing damage occurs. During the heat of the day the bifoliolate leaflets are held in a conduplicate way to avoid excessive insolation. *Z. decumbens* var. *decumbens* occurs on limestone, sand or shale flats and is common on quartz or dolerite hills, in dry river courses and sandy washes. In the Keimoes, Kakamas area this species occurs as a weed in vineyards. Flowering period is from April to October and fruits are found almost throughout the year. Although there is

an abundance of fruits on fruiting specimens, mature seeds are found on herbarium specimens which are collected in late autumn. This indicates that seeds need several months on the mother plant to mature. The question remains why is it necessary for seeds to remain so long inside the fruit and attached to the mother plant before maturation.

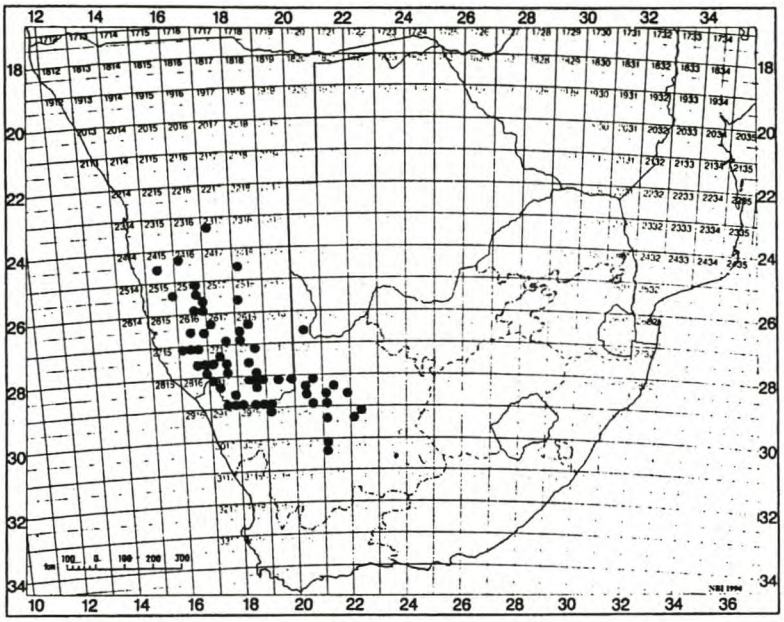


Figure 7.15.2. Geographical distribution of *Z. decumbens* var. *decumbens*.

Material examined

–2317 (Rehoboth): Naugeries, district Rehoboth (–AC), *Giess 2092* (PRE, WIND).

–2415 (Sossusvlei): Tsaukhaib Diamond Area (–CB), *Hardy & Venter 4464* (PRE, WIND).

–2416 (Maltahohe): Neuras, Maltahohe district (–AC), *Strey 2318* (BOL, SAM, WIND).

–2418 (Stampriet): 13 M ENE of Mariental on road to Witbooisvlei (–CA), *De Winter 3545* (PRE, WIND).

–2515 (Awasib): 2 M E of sand dunes, Awisib Mountains (–BD), *Seely & Robinson 325* (WIND).

–2516 (Helmeringhausen): Kleinfontein : MAL 81 (–BA/BB), *Van Zyl 3807* (NBG, PRE, WIND); Naudaus/Duwisib: MAL 76/84 (–BC), *Volk 12667* (WIND); Rooiberg Suid: MAL 77 (–BC), *Steyn 9959* (PRE, WIND); Chamchawib (–DB*), Merxmüller & Giess 2814* (WIND); E slopes of mountain on Barby: BET 26 (–DC), *Giess 8838* (PRE); 10 km N of Helmeringhausen towards Maltahohe (–DD), *Jurgens 22097* (PRE); Schwarzkalkrand on Congella: BET 11 (–DD), *Giess 10191* (PRE, WIND); Limestone flats on Goais: BET 13, S of Helmeringhausen (–DD), *Giess 8803* (PRE, WIND).

–2518 (Tses): Mukarob 14, N of Keetmanshoop (–CA), *Van Zyl 3779* (NBG), *Giess, Volk & Bleissner 6831* (WIND).

–2615 (Luderitz): Sandy plain at Haalenberg (–CA), *Dinter 4075* (BOL, NBG, PRE, SAM), *Merxmüller & Giess 3118* (PRE, WIND).

–2616 (Aus): Quartsite hill at Aus (–CB), *Pearson 8033* (BOL); Aisis, 39 M S of Aus on road to Witputz (–CB), *De Winter & Giess 6300* (WIND); Near farmhouse on Plateau: LU 38 (–CB), *Wiss 2538* (PRE, WIND); 34 km W of Goageb, near Guibes (–DB), *Van Zyl 3856* (NBG, WIND); Next to road at Kuibis : BET 168 (–DB), *Kraeusel/Wiss 2005* (WIND).

–2617 (Bethanie): 12 km W of Goageb on Bucholzbrun: BET 14 (–AC), *Van Zyl 3853* (NBG, WIND); 12 km W of Seeheim on road to Aus (–DC), *Van Zyl 3847* NBG, WIND).

–2618 (Keetmanshoop): Blaukehl Sud 142, NE of Keetmanshoop (–AD), *Van Zyl 3770* (NBG, WIND); Kokerboomwoud, 12 km NE of Keetmanshoop (–CA), *Van Zyl 3768* (NBG, WIND); 9 M NE of Spitskop on road Keetmanshoop to Koes (–CC), *Codd 5899* (WIND).

–2620 (Twee Rivieren): A few km along the Rietfontein road from Andriesvale (–CB), *Clarke 675* (PRE).

–2716 (Witputz): Diamantgebiet 1. Tsaus Sudwestseite (–AA), *Wendt C/2* (WIND); Diamantgebiet 1. Tsaus Spinnenberg (–AA), *Wendt 13/1* (WIND); Arutal 25, S of Aus (–AB), *Van Zyl 3883* (NBG, WIND); On granitic gravel on Pockenbank: LU 68 (–BA), *Giess, Volk & Bleissner 5314* (WIND); 71 M S of Aus on road to Witputz (–DA), *De Winter & Giess 6300* (PRE, WIND); Loam flats on Arimas: LU 83 (–DB), *Merxmüller & Giess 28889* (WIND); Sandy flats near Naute (–DD), *Van Zyl 3845* (NBG, WIND); Namuskloof: LU 88 (–DD), *Kraeusel/Wiss 2072* (WIND).

–2717 (Chamaites): At the Ai-Ais connection to the road between Holoog and Gorges (–BD), *Van Zyl 3842* (NBG, WIND); In the Nuobriver on State land, 3 km S of border of farm Uitsig (–CA), *Wendt in Giess 14767* (WIND); View Point at Fish river canyon (–DA), *Balsinhas & Kersberg 2027* (WIND); Start of Fish river hiking trail (–DA), *Van Jaarsveld 8766* (PRE), *Van Zyl 3840* (NBG); ± 6 km E of Ai-Ais on road R97 (–DC), *Van Zyl 4359* (NBG); Kwaggasnek, SE of Ai-Ais (–DC), *Van Zyl 3831, 3835* (NBG, S, WIND) ; At Ai-Ais Resort (–DC), *Van Zyl 3833* (NBG, WIND).

–2718 (Grunau): Kraikloof, Kuchanas, Great Karas Mountains (–BA), *Ôrtendahl 530* (BOL, PRE); Kalkfläche near Grabwater (–CB), *Dinter 5051* (NBG, SAM); Kalkfontein Sud (–DC), *Dinter 4740* (PRE); Kanus Station, NW of Karasburg (–DC), *Van Zyl 3766* (NBG).

–2817 (Vioolsdrif): Between confluence of Boom and Dabimub rivers with the Orange (–AA), *Van Zyl 4475* (NBG, WIND); Tatasberge, Richtersveld (–AD), *Herre s.n. (STE-U 12009* in NBG); On banks of Orange River at Aussenkehr se Berge (–AD), *Van Zyl 4327* (NBG); 22 km N of Noordoewer next to B2 (–DB), *Van Zyl 3759* (NBG); Vyfmylpoort, S of Vioolsdrif (–DC), *Van Zyl 3826* (NBG); At Vioolsdrif (–DC), *Van der Schijff 8170* (PRE); Swartberg Mine between Steinkopf and Vioolsdrif (–DD), *Van Wyk 6527* (PRE).

–2818 (Warmbad): Bondelswarts area, NE of Karuchas *(–AB), Van Zyl 3761* (NBG, WIND); One mile from Karasburg on road to Upington (–BA), *Balsinhas & Kersberg* 2034 (WIND); Naruchas: WAR 49 (–BB), *Giess 14494 A* (WIND); At Warmbad (–BC), *Galpin 14128* (PRE); In hills at Vuurdood (–CC), *Schlechter 11446* (BOL, GRA); Henkries, Little Bushmanland (–CC), *Schlechter s.n.* (BOL 49132), *Phillips 1581* (NBG, SAM); Witbank, Bushmanland (–DC), *Le Roux 2559* (NBG); 10 M S of Goodhouse (–DD), *Schleben 9102* (PRE).

–2819 (Ariamsvlei): Kokerboom (–AB), *Pillans 5881* (BOL); 2 M N of farmhouse on Kentucky: WAR 80 (–AB), *Giess, Volk & Bleissner 7091* (WIND); Sandy flats and black hills, W of Ariamsvlei, district Warmbad (–BB), *Merxmüller & Giess 750* (WIND); 2.5 km S of the Orange River at Pelladrift (–CC), *Le Roux 3695* NBG).

–2820 (Kakamas): Riemvastmaak, Upington district (–AD), *Barnard s.n.* (SAM 36116); Smalvisch, Gordonia (–BA), *MacDonald 76/56* (NBG, PRE); Augrabies National Park (–CB), *Zietsman 640* (PRE), *Compton 24451* (NBG), *Rycroft 1683* (NBG); On banks of Orange River near Kakamas (–DC), *Lewis 195* (SAM); Vaalgras, Kakamas (–DC), *Botha 2983* (PRE); North of Orange River, Kakamas (–DC), *Middlemost NBG 7530* (NBG).

–2821 (Upington): At Upington (–AD), *Broom s.n.* (GRA 7400); Dyasonsklip, between Upington and Keimoes (–CA), *Glover s.n.* (BOL13349); 64 km N of Kenhardt on R27 (–CC), *Van Zyl 4310* (NBG, PRE); Vollgraafsig, 55 m SE of Upington (–DB), *Werger 141* (WIND).

–2919 (Pofadder): On the outskirts of Pella on road to Pelladrift (–AA), *Van Zyl 4317* (NBG); S slopes of Pellaberg East (–AA), *Van Jaarsveld & Patterson s.n.* (NBG 141101).

–2921 (Kenhardt): At Kenhardt (–AC), *Marloth 7947* (PRE).

–2922 (Prieska): Limestone slopes at Lelyk's Stad, Hay (–AB), *Acocks 5754* (BOL); Quartsite hills near the Oranjerivier on the Draghoender to Koegas road (–AC), *Lindeberg & Acocks 1164* (BOL).

–3021 (Vanwyksvlei): 2 km S of Nuwerus house on the road to Swartkop (–AA), *Le Roux & Lloyd 250* (PRE); Shale flats on Hartogskloof between Vanwyksvlei and Brandvlei (–AC), *Hugo 354* (NBG).

–3023 (Britstown): At Britstown (–DA), *Pole-Evans H18811* (PRE).

§ Alata Huysst., *Morphologisch-systematische Studien über die Gattung Zygophyllum*……: 63 (1937).

Type species: *Z. longistipulatum* Schinz

Van Huyssteen (1937) originally divided *§ Alata* into three subsections, two of which remain: subsection *Alata*, dealing with southern African species of *Zygophyllum,* and subsection *Dumosa* Popov dealing with **non** southern African species. The third subsection, *Morgsana* Huysst. is transferred to the subgenus *Zygophyllum* because of its different floral and fruit morphology.

Subsection Alata Huysst., *Morphologisch-systematische Studien Studien über die Gattung Zygophyllum……:* 64 (1937).

Type species: *Z. longistipulatum* Schinz.

This subsection comprises three species characterized by winged fruits. They are *Z. microcarpum* Cham., *Z. rigidum* Schinz and *Z. longistipulatum* Schinz. Table 7.4 summarizes the characters of the species in subsection *Alata.*

Diagnostic features of subsection Alata

White, two-armed hairs present
Young stems with prominent ventral grooves
Leaves bifoliolate, sub-petiolate or petiolate, leaflets widely or narrowly obovate
Stipules subulate, white, stiff, two on ventral and two on dorsal side, sometimes alternately free or fused on ventral side of stems
Nectar disc smooth, 10-angled, with ten small lobes orientated downwards, situated on the side of disc
Staminal scales simple, apex truncate, denticulate and enfolding alternate filaments
Mature fruits 5-winged, wings undulate or straight
Seeds compressed pyriform

Key to species in subsection A*lata*:

1a Glabrous shrub, leaves sub-petiolate with short petioles of 0.5–2.0 mm, one stipule present on dorsal side of young stems, sometimes with notched apex. .....*Z. rigidum*

1b Shrubs with white, two-armed hairs present, leaves with petiole of 4–10 mm long, two stipules present on dorsal side of young stems..... 2

2a Mature fruit drooping, hidden between leaves, small, 2–3 x 7.5 mm, with 5 straight wings and 1-seeded mericarps .....*Z. longistiputalum*

2b Mature fruit erect or semi-erect, never hidden, large and showy, 7–8 x 11–13 mm, with 5 undulate wings and 1–2 seeded mericarps .....*Z. microcarpum*

Table 7.4. Characters of the species in subsection *Alata*

Z. RIGIDUM	Z. MICROCARPUM	Z. LONGISTIPULATUM
erect shrub, 1.5 x 1.5 m	erect shrub, 1.5 x 1.0 m	erect or spreading shrub, 1 x 1 m
glabrous or rarely sparsely hairy on young parts	white hairy, becoming glabrescent with age	white hairy
leaflets widely obovate, 8–15 x 5–9 mm	leaflets narrowly obovate, 6–11 x 2–3 mm	leaflets narrowly obovate, 5–9 x 3–4 mm
petiole 0.5—2 mm long	petiole 4—8 mm long	petiole 4—10 mm long
stipules triangular, 1.0—1.5 mm long, 2 ventral and 2 dorsal, stipules rarely fused	stipules subulate, 1.5—2 mm long, 2 ventral and 2 dorsal, stipules rarely fused	stipules subulate, 2—3 mm long, 2 ventral and 2 dorsal, stipules rarely fused
petals spathulate, yellow and orange, 7–10 x 3 mm	petals spathulate, white and yellow, 7.0–8.0 x 1.5–2.5 mm	petals spathulate, white, yellow and orange, 5.0–7.0 x 1.5–2.5 mm
fruits droopy, wings usually undulate, 5–8 x 12–18 mm	fruits erect or semi-erect, wings usually undulate, 6–9 x 11–13 mm	fruits droopy, wings always straight, 2.0–3.0 x 7.5–10.0 mm
seeds 2–3 x 1.5–1.8 mm, mericarps 1—3-seeded	seeds 3–4 x 2.0–2.5 mm, mericarps 1or 2-seeded	seeds 1.5–2.0 x 1.0–1.5 mm, mericarps 1-seeded

7.16 Zygophyllum microcarpum *Cham.* in Linnaea 5 : 46 (1830); Sond.: 363 (1860); Huysst.: 63 (1937); A.Schreib.: 90 (1963); A.Schreib. in Merxm.: 17 (1966). TYPE - Western Cape: "*Z. microcarpum* Lichtenstein, Olifantsrivier, specimen ab auctore missum!" (all annotated in Sonder's handwriting), (S!, lecto., designated here), (8093 in B-Willd!, syn.).

Z. microcarpum *Cham.* var. **macrocarpum** *Loes.* in Dinter: 25 : 210 (1928), nom nud; Sandverhaar, *Dinter 1190* (SAM!); Z. microcarpum Cham. var. **acrocarpum** Loes. in Dinter ex Range: 36 : 248 (1934), error typo.

Zygophyllum garipense *E Mey.* in Drège: nom. nud.: 230 (1843); Natvoet, *Drège 3180* (KIEL!, P!, Z!); Zwischen Natvoet und Garip, 1000–1500 f , *Drège s.n.* (S, annotated by E.Meyer and Sonder " Z. microcarpum Licht.", TCD!).

Zygophyllum garipinum *Max Schlecht.* Henkries, *Schlechter s.n.* (Z!). nom nud.

Erect or spreading, many stemmed shrub, reaching a height of 1.5 m and a diameter of 1.0 m or more, young parts densely or sparsely white hairy with two-armed trichomes, becoming glabrescent with age. *Stems:* old stems leafless, dark to light gray or white, often tinted yellowish, bark finely cracked, nodes swollen; young stems green, leafy, with a prominent ventral groove. *Leaves* opposite, petiolate, khaki or green, bifoliolate; leaflets articulate, narrowly obovate, apex acute, mucronate, base usually cuneate, 6–11 x 2–3 mm; rachis apex filamentous, minute, 1 mm long; petiole articulate, narrowly obovate, flat, adaxially grooved, 4–8 x 1–2 mm long; stipules subulate, base thickened, with a tapering apex, white and stiff, two on ventral side or alternately two (free) or one (fused) on stem and two on dorsal side of stem, base semi-permanent 1.5–2.0 x 1.0–2.0 mm. *Flowers* solitary, axillary. *Pedicel* 4 mm long, elongating in fruit to 10 mm. *Sepals* 5, ovate or obovate, articulate, membranous margined, outer ones slightly succulent, cucullate, 2.0–3.5 x 1.5 mm. *Petals* 5, spathulate, apex round, base with a long claw, white or pale yellow, 7–8 x 1.5–2.5 mm. *Nectar disc* smooth, 10-angled, with10 small lobes, orientated downwards at base. *Stamens* 10; filaments terete, 4—6 mm long, pollen orange; staminal scales 10, nearly transparent, alternately with different orientation, apex of antipetalous scale enfolding filament, antisepalous scale open at apex, obovate, apex truncate, denticulate, side margins entire, base rounded, 2–2.5 x 2–

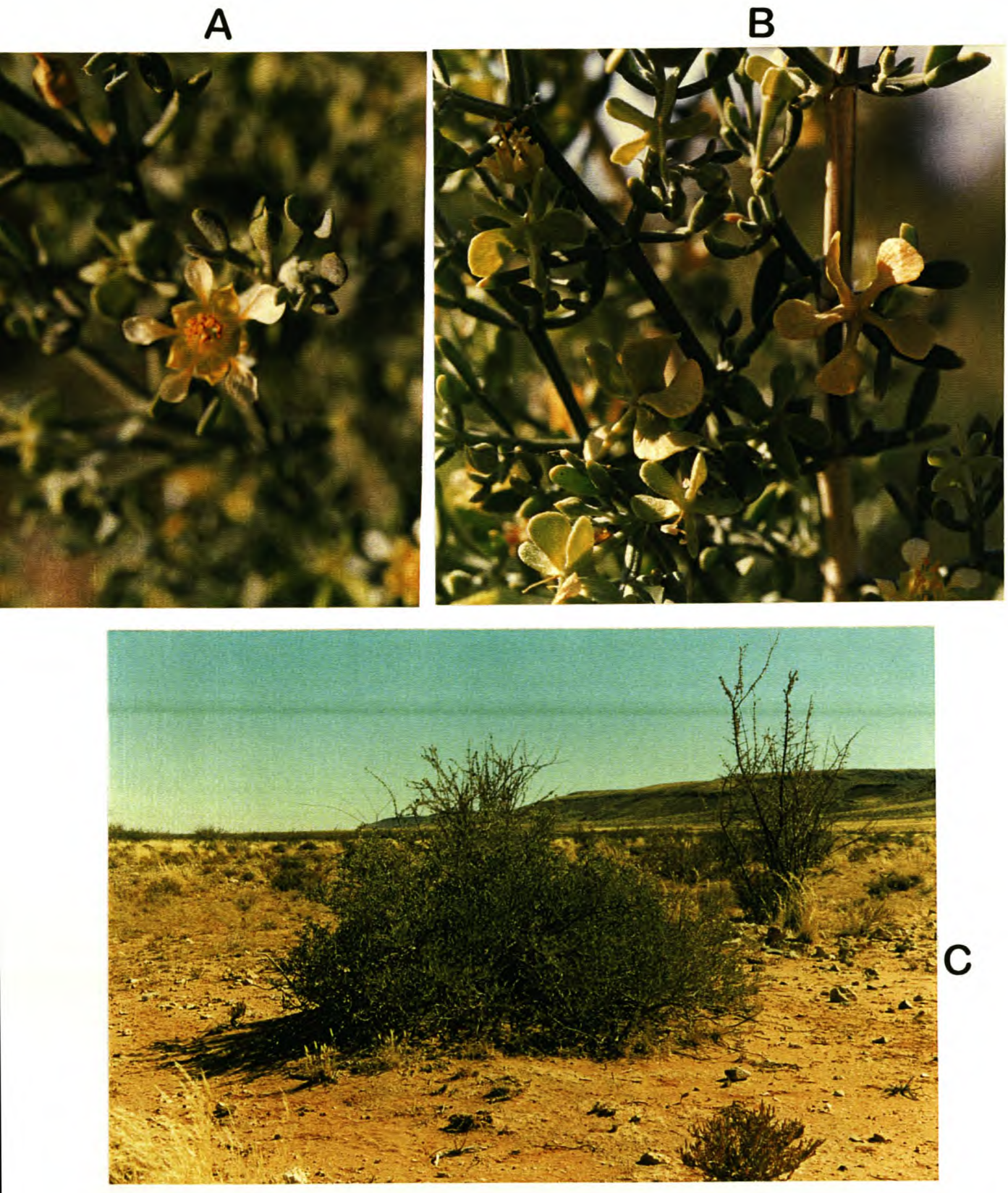


Figure 7.16.1. *Z. microcarpum*. A, twig with flowers, leaves and fruit, *Van Zyl 3913*; B, twig displaying the undulate wings of mature fruits, the long petioles of the leaves and the distinct ventral grooves on young stems, *Van Zyl 3913*; C, habit near Schakalskuppe, Namibia, *Van Zyl 3859*.

2.5 mm, ± 1/2 the length of the filament. *Ovary* oblong, 5-parted, densely white-haired, apex retuse; style terete; stigma simple. *Fruit* an erect or semi-erect, oblong, septicidal schizocarp, 5-winged, wings undulate and propellate (twisted like a propeller), yellow or reddish-orange when mature, apex with a deep, narrow or wide V, 11–13 x 7–8 mm, breaking up in 5 compressed, reticulate veined mericarps. *Seed* compressed pyriform, 1–2 per locule, 3–4 x 2–2.5 mm, brown, when immature attached by a long funicle, testa granular, nearly transparent when wet and producing structured mucilage with short, spiral inclusions that seem to unravel at the apex (Figure 7.16.1).

Diagnostic features and affinities

Z. microcarpum is distinguished by its erect or semi-erect, 5-winged fruits which are prominently coloured yellow or reddish-orange when mature and which usually have undulate wings, by its relatively long petioles (4–8 mm long) and by its narrowly obovate leaflets (2—3 mm wide). *Z. microcarpum* is allied to *Z. rigidum* and *Z. longistipulare* which have similar floral morphologies and display similar spathulate petals, staminal scales and nectar discs. They differ in leaf and fruit morphology. *Z. rigidum* has very short petioles of 0.5—2.0 mm in length and *Z. macrocarpum* and *Z. longistipulare* have longer petioles of 4–10 mm in length. The leaflets *of Z. rigidum* are 5—9 mm wide, those of *Z. microcarpum and Z. longistipulatum* are 2—3 mm and 3—4 mm wide respectively. The fruits of *Z. microcarpum* and *Z. rigidum* are the largest, usually with undulate wings, and range in size from 5—9 x 11—18 mm, whereas those of *Z. longistipulare* are always smaller and wider than long, with straight wings and range from 2.0–3.0 x 7.5—10.0 mm in size. The fruits *of Z. microcarpum* is carried in an erect or semi-erect manner whereas those of *Z. rigidum* and *Z. longistipulatum* are drooping. Strangely the epithet probably refers to the large fruit. Table 3.4 summarizes the characters of the species in § *Alata*, subsection *Alata*.

Distribution and ecology

Z. microcarpum is widespread in the southern parts of Namibia and central parts of South Africa from Maltahohe, Namibia in the north to Oudtshoorn in the south and as far east as Jagersfontein (Figure 7.16.2). In Namibia it occurs in the **Nama Karoo Biome** (Irish 1994). In South Africa it occurs in a vegetation classified as **Savanna Biome**: Kalahari Plains Thorn Bushveld and Kimberley Thorn Bushveld (Van Rooyen & Bredenkamp 1996); **Nama Karoo Biome**, in all six categories: Bushmanland Nama Karoo, Upper Nama Karoo, Orange River Nama Karoo, Eastern Mixed Nama Karoo, Great Nama Karoo and Central Lower Nama Karoo (Hoffman 1996); **Succulent Karoo Biome**: Upland Succulent Karoo, Lowland Succulent Karoo and Little Succulent Karoo (Hoffman 1996). The Succulent Karoo Biome receives rain during winter months with extremely hot and dry summers whereas the Nama Karoo is predominantly a summer rainfall area. Flowers and fruits are found throughout the year, although there is a flowering peak from July to August. This species is probably not palatable, because grazing damage is rare. Stock losses due to grazing of this species is reported by Eberhard (1977). Due to its widespread distribution, large populations and probable aversion by stock, this species is at present not threatened.

Common names: Gannabos, Armoedsbos, Sandrapuis and Ouooibos.

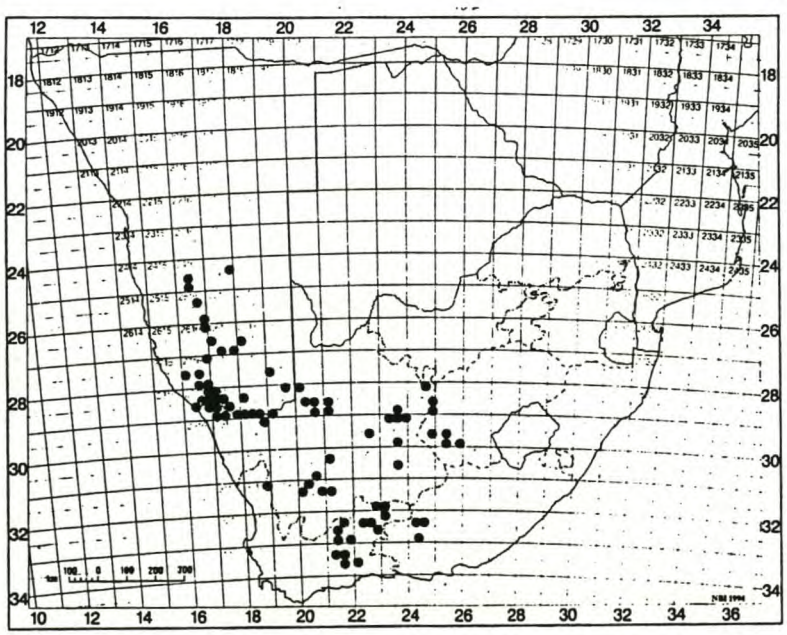


Figure 7.16.2. Geographical distribution of *Z. microcarpum.*

Specimens examined

–2416 (Maltahohe): Friedland, district Maltahohe (–CB), *Walter 1918* (WIND); Uitkoms 185, district Maltahohe (–CD), *Muller 1335* (WIND).

–2417 (Mariental): Salzbrunn, N of Mariental (–BD), *Pole-Evans H19367* (PRE).

–2516 (Helmeringhausen): Naudauss 76, Duwisib 84 (–BC), *Volk 12771* (WIND); Goais, S of Helmeringhausen (–DD), *Giess 8813* (PRE, WIND).

–2616 (Aus): Mooifotein, BET 50 (–BB), *Giess, Volk & Bleissner 5506* (PRE, WIND).

–2617 (Bethanie): Bucholtzbrunn, SW of Bethanie (–CA), *Dinter 4190* (C, SAM); Sandverhaar BET 80 (–CD), *Van Zyl 3849* (NBG); *Owen-Smith 1124* (WIND); *Dinter 1190* (SAM); Seeheim (–DD), *Dinter 4208* (C, SAM).

–2618 (Keetmanshoop): Floodplains of Skaaprivier at Naute Dam (–CA), *Merxmüller & Giess 28890* (WIND).

–2716 (Witputz): Udabib mountain (–BB), *Muller 807* (PRE, WIND); Uguchab river area NW of Aurus mountains (–CA), *Oliver 10180* (NBG); Rooiberg, Diamantgebiet 1 (–DA), *Wendt 23/4* (WIND); Spitskop, NW of Rosh Pinah (–DC), *Van Berkel 542/W16* (NBG, WIND); River bed at Namuskluft LU 88 (–DD), *Giess 12906* (WIND); *Van Zyl 4389* (NBG, PRE); Plateau, near Rosh Pinah (–DD), *Walter 144* (WIND).

–2719 (Tranental): Blinkoog, NE of Karasburg (–CA), *Walter 2406* (WIND).

–2816 (Oranjemund): Orange River bed at Sendelingsdrift (–BB), *Merxmüller & Giess 3272* (PRE, WIND); *Metelerkamp 396* (BOL); *Herre STE 12016* (NBG); *Range 1567* (BOL); Banks of Orange River at Lorelei Mine (–BB), *De Winter & Giess 6371* (WIND); Uferterasse im Galeriewald at Lorelei Mine (–BB), *Giess, Volk & Bleissner 5408* (WIND); By den Hausern at Lorelei Mine (–BB), *Giess, Volk & Bleissner 5386* (WIND); S of Rosh Pinah on road to Ockta Mine (–BB), *Van Zyl 3908* (NBG, PRE); At Ockta Mine Office (–BB), *Van Zyl 3913* (NBG, PRE); ± 6 km E of Brandkaros in dry river bed (–BC), *Drijfhout 2884* (NBG, PRE); Grasvlakte turn off to Helskloof (–BD), *Van Zyl 3915* (NBG, PRE); Between Bloeddrif and Anniskop, Richtersveld (–BD), *Van Zyl 4068* (NBG, S); N of Bloeddrif on the Orange River (–BD), *Van der Westhuizen 224/82* (NBG); Oranjehange gegen Hohenfels bei Oranjemund (–CB), *Merxmüller & Giess 2269* (WIND); Oltenhout, Karagaskloof (–DB), *Thompson & Le Roux 358* (NBG, PRE).

–2817 (Vioolsdrif): Between Blokwerf and Dabimub confluence with the Orange River (–AA), *Van Zyl 4331* (NBG); Between the confluence of the Dabimub and Boom River with the Orange River (–AA), *Van Zyl 4338* (NBG, PRE); 5 km W of Dabimub river mouth (–AA), *Zietsman 736* (PRE); Am Oranjeufer, 5 km W of Nuob River (–AA), *Giess 13802* (WIND); Blokwerf, between confluence of Fish and Dabimub Rivers with Orange River (–AA), *Van Zyl 4377* (NBG); S of Doornpoort (–AC), *Marloth 12316* (PRE); On the Orange River at Aussenkjer se berge (–AD), *Van Zyl 4326* (NBG, PRE); 2 km S of Ploegberg (–CA), *Zietsman 810* (PRE); Holgatsrivierloop at N base of Wildeperderant (–CA), *Van Zyl 4054* (NBG, PRE); Spitskloof, N of Lekkersing (–CC), *Van Zyl 4050* (NBG, PRE); Lekkersing (–CC), *Herre STE 19053* (NBG); ± 20 km N of Lekkersing on road to

Khubus (–CC), *Van Zyl 4142* (NBG, PRE); Ganagurib, Helskloof (–CD), *Herre STE 12015* (NBG); Alluvial flats 17 km W of Noordoewer (–DA), *Giess 14527* (WIND); *Giess 14528* (WIND); Beside Orange River on western side of Vioolsdrift (–DD), *Craven 1168* (WIND).

–2818 (Warmbad): Bruinheuwel WAR 257 (–AC), *Giess, Volk & Bleissner 6935* (PRE, WIND); Henkries (–CC), *Schlechter 15* (BOL); Banks of Orange River at Goodhouse (–CD), *Thorne SAM 52431* (SAM); Gaidib 46, SW of Warmbad (–CD), *Dinter 5125* (PRE, SAM); Old fields at Goodhouse (–CD), *Van Zyl 4320* (NBG, PRE, S); *Kruger 22* (PRE); Banks of Orange River at Witbank, Boesmanland (–DC), *Le Roux 2541* (NBG).

–2819 (Ariamsvlei): 60 M E of Karasburg (–BA), *Hardy 1937* (WIND); Orange River at Pella Drift (–CC), *Taylor 8442* (NBG, PRE); Pump station at Pella Drift (–CC), *Van Zyl 4318* (NBG, PRE).

–2820 (Kakamas): Pan N of Aries, Upington (–AA), *Barnard SAM 32664* (SAM); Orange River banks in Aughrabies National Park (–CB), *Werger 366* (PRE, WIND); *Barker 8303* (NBG); Wabrand, Aughrabies (–CB), *Meyer B21/7288* (PRE); Near Neushoek Stasie between Keimoes and Aughrabies (–DA), *Taylor 9033* (NBG, PRE); Perde Eiland, Kakamas (–DC), *Wasserfall 1141* (PRE).

–2821 (Upington): Louisvale, Kenhardt district (–CA), *Sekwodery STE 25981* (NBG); Near Neilersdrift, Keimoes (–CC), *Van Zyl 4312* (NBG, PRE, S).

–2823 (Griekwastad): ± 3 km from Strydenburg on road to Driekop (–DC), *Glen 1441* (PRE).

–2824 (Kimberley): Between Kubitje Griqualand and Klipaar (–BA*), Pole-Evans 2150* (PRE); On limestones near Honeynest Kloof, Kimberley (–DB), *Wayland PRE 45854* (PRE); Surface limestone on Benaawdheidsfontein (–DD*), Hafstrom & Acocks 982* (BOL, PRE).

–2918 (Gamoep): Dry river bed between Wortel and Aggenys (–BB), *Pearson 3030* (BOL, SAM).

–2922 (Prieska): At Prieska (–DA), *Bryant STE 18324* (NBG).

–2923 (Douglas): Reads Drift, Herbert district (–AB), *Acocks 1939* (PRE); Limestone ridge on Maselsfontein, Douglas (–BA), *MacDonald 77/87* (NBG); *Anderson 637d* (BOL, SAM); 7 m NW of Douglas (–BB), *Leistner 1308* (PRE); 6 km from Strydenburg on road to Prieska (–DC), *Herman 630* (PRE).

–2924 (Hopetown): 8 km from Luckhoff on Petrusville road (–DB), *Story 1212* (PRE).

–2925 (Jagersfontein): Alkaline soil at Fauresmith (–CB), *McLoughlin 103* (BOL); Reserve at Fauresmith (–CD), *Henrici 2294* (PRE); *Henrici 2670* (PRE); *Henrici 2726* (PRE); Palmietfontein, near Luckhoff town lands (–DD), *Smith 5338* (PRE).

–3020 (Brandvlei): Bleskrans, 5 km N of Kareekop (–DC), *Hugo 382* (NBG).

–3021 (Vanwyksvlei): Jan Louwskolk, S of Zwartkop (–AC), *Hugo 360* (NBG).

–3023 (Britstown): Britstown district (–DA), *Loots STE 81758* (NBG); S of Britstown (–DA), *Taylor 900* (BOL).

–3118 (Vanrhynsdorp): Along Gemsbokrivier, Knersvlakte (–BB), *Van Zyl 4582* (NBG).

–3120 (Williston): 55 km NE of Calvinia on R27 (–AB), *Van Zyl 4309* (NBG, PRE, S); ± 20 m E of Calvinia on Williston road (–AC), *Barker 10559* (NBG); Heeltevrede, 14 km W of Williston (–BD), *Powrie 871* (NBG).

–3121 (Frazerburg): 10 km from Williston on road to Frazerburg (–AC), *Grobbelaar 2180* (PRE).

–3122 (Loxton): Rhinosterkop, Beaufort West (–DD), *Zeyher 1206* (SAM); *Zeyher 279 or SAM 30014, SAM 30016* (SAM).

–3123 (Victoria West): Kraaifontein, near Kromrivier Station, Beaufort West (–CC), *Kingon NBG 85052* (NBG).

–3221 (Merweville): Near Bulwater turn off (–BC), *Van Zyl 3731* (NBG); De Lust (–CB), *Van Zyl 3728* (NBG); Between Kogelfontein and Geelpoort se Nek (–CD), *Van Zyl 3723* (NBG); Frazerburg road (–DD), *Smith 2498* (PRE); Near Leeuwgamka (–DD), *Van Zyl 4160* (NBG, PRE, S).

–3222 (Beaufort West): Klipbank Siding (–AD), *Viviers 1530* (BOL); 10 M S of Beaufort West on way to Oudshoorn (–BC), *Theron & Van der Schijff 2192* (PRE); Kraanvoëlkuil, Beaufort West (–BC), *Jordaan STE 26404* (NBG); Hoenderverdriet, 37 km SE of Beaufort West (–DB), *Van Zyl 4168* (NBG, PRE).

–3223 (Rietbron): Near Pretoriuskuil, on Beaufort West to Aberdeen road (–DA), *Van Zyl 4171* (NBG, PRE).

–3224 (Graaf-Reinet): Gannalaagte in Karoo Nature Reserve (–AD), *Linger 2109* (PRE); *Allardice 1553* (PRE); *Palmer 580* (GRA, PRE); Roadside S of Graaf-Reinet (–BC), *Bolus 212* (BOL); In clay near Graaf-Reinet (–BC), *MacOwan 1760* (SAM); Near Aberdeen 4918 (–CD), *Barker 4918* (NBG).

–3321 (Ladismith): Dry stream beds in Bosluiskloof Pass (–AD), *Hardy 264* (PRE); Bosluiskloof, site of Gamkapoort dam (–AD), *Odendaal STE 31759* (NBG). Gamkapoort Nature Reserve, where road runs into Bosluiskloof river bed (–BC), *Laidler 620* (NBG, PRE); Flats near Gamkapoort Dam (–BC), *Van Zyl 3702* (NBG, PRE); 31 m from Prins Albert on Ladismith road (–BC), *Wells 3755* (GRA, PRE); Welgerust, S of Calitzdorp (–DA), *Van Zyl 4532* (NBG, PRE).

–3322 Oudshoorn): 9 m W of Oudshoorn on Calitzdorp road (–CA), *Zinn SAM 66958* (SAM).

Without precise locality or unknown locality: Between Bosluiskloof and Prins Albert, *Lewis SAM 69036* (PRE); Rietfontein, Barckly West, *Acocks 728* (PRE); Z. garipense, *Drège s.n.* (BOL 49351, KIEL, PRE 9149); Nabas, Richtersveld, *Hardy 2595* (PRE); Zwischen Natvoet und Garip, *Drège s.n.* (TCD); Orange River, *Dinter STE 17374* (NBG); Sunnyside, Beaufort West, *Esterhuysen 2738* (BOL); Omdraaivlei, Prieska, *Bryant 1183* (PRE); Near Hofmeyer, *Theron 921* (PRE); Between Modderdrift and Sjambok River, *Pillans* (BOL); Somerset East, *Drège L. 485* (GRA); Gannapoort, Kenhardt, *Schlieben 8945* (PRE); Between Brooklyn and Graaf-Reinet, *Pole-Evans 2535* (PRE); Gordonia district, *Kotze 859* (PRE); Between Modderfontein and Doornpoort, *Pearson 5987* (SAM); Nautgerus, Rehoboth , *Walter 1846* (WIND); Ufer am Orange, *Range 1567* (SAM); Arisdrift am Orange River, *Schenck 262* (PRE); South of Graaf-Reinet, *Bolus 212* (GRA); Namaqualand, *Wyly s.n.* (TCD).

7.17 **Zygophyllum rigidum** *Schinz* in Verhandlungen des Botanischen Vereins.....29 : 55 (1888); Huysst.: 76 (1937); A.Schreib.: 58 (1963). Locality – Namibia: Aus, Gross Namaland. No specimen cited. TYPE - Namibia: Aus, Gross Namaland, *Schinz 1029* (Z!, neo, designated here)

Zygophyllum suffruticosum *Schinz:* 188 (1894); Huysst.: 63 (1937); A.Schreib.: 106 (1963); A.Schreib in Merxm.: 18 (1966). TYPE - Namibia: Aus in Gross Namaland, *Schinz 1029* (Z!, lecto, designated here; Z!).

Zygophyllum latialatum *Engl.*: 244 (1897); Huysst.: 63 (1937); A.Schreib.: 106 (1963); A.Schreib. in Merxm.: 19 (1966); ex descr. TYPE - Namibia: Stolzenfels-Rieftontein, (2819BC - Ariamsvlei), *Graf Pfeil 90 (B†)*; not traced in the following Herbaria either: B, C, GB, H, KIEL, L, M, MB, UPS, W, Z.

Although Schinz (1888) did not cite any specimen in his description of *Z. rigidum*, the descriptions of *Z. rigidum* Schinz and *Z. suffruticosum* Schinz (1894) and even that of *Z. latialatum* Engl. (1897) are very clear and I have no doubt that they are conspecific.

Erect, many stemmed, glabrous, woody shrub, reaching a height of 1.5 m and a diameter of 1.5 m, rarely with sparse, white, two-armed hairs present on young parts. *Stems:* old stems leafless, bark dark gray, finely cracked, nodes swollen; younger stems greenish or cream coloured, leafy, with a well developed ventral groove. *Leaves* opposite, subpetiolate, bifoliolate, glossy, dark-green, copper or burgundy coloured; leaflets articulate, widely obovate, apex mucronate, base rounded or cuneate, 8–15 x 5–9 mm; rachis apex filamentous, minute; petiole articulate, 0.3–2.0 mm long; stipules triangular, acuminate, white, rigid, base thickened and semi-permanent, on ventral side usually two or at alternate nodes along the stem, two (free) or one (fused), and on dorsal side of stem one only, sometimes shallowly notched at apex, 1–1.5 x 1–1.5 mm. *Flowers* solitary, axillary. *Pedicel* 4—8 mm long, elongating in fruit to 10 mm. *Sepals* 5, ovate or obovate, membranous margined, articulate, outer ones cuculate, 4.5–7 x 2–2.5 mm. *Petals* 5, spathulate, apex round, base with a long claw, pale yellow or orange, withering to white, 7–10 x 3 mm. *Nectar disc* fleshy, smooth, alternately 5-angled and 5-lobed, sloping slightly towards its periphery and displaying 10 small lobes that are orientated downwards at its base. *Stamens* 10; filaments terete, 4—6 mm long; staminal scales 10, simple, nearly transparent, alternately with different orientation, apex of antipetapus scale enfolding the filament (Figure 7.18.1.G), antisepalous scale open at apex (Figure 7.18.1.F), oblong, apex truncate, denticulate, lateral margins entire, base rounded, 2–2.5 x 2 mm, ± ½ the length of the filament. *Ovary* obovate, 5-parted, upper third glabrescent between the lobes, apex retuse; style terete; stigma simple. *Fruit* a droopy, septicidal schizocarp, 5-winged, wings

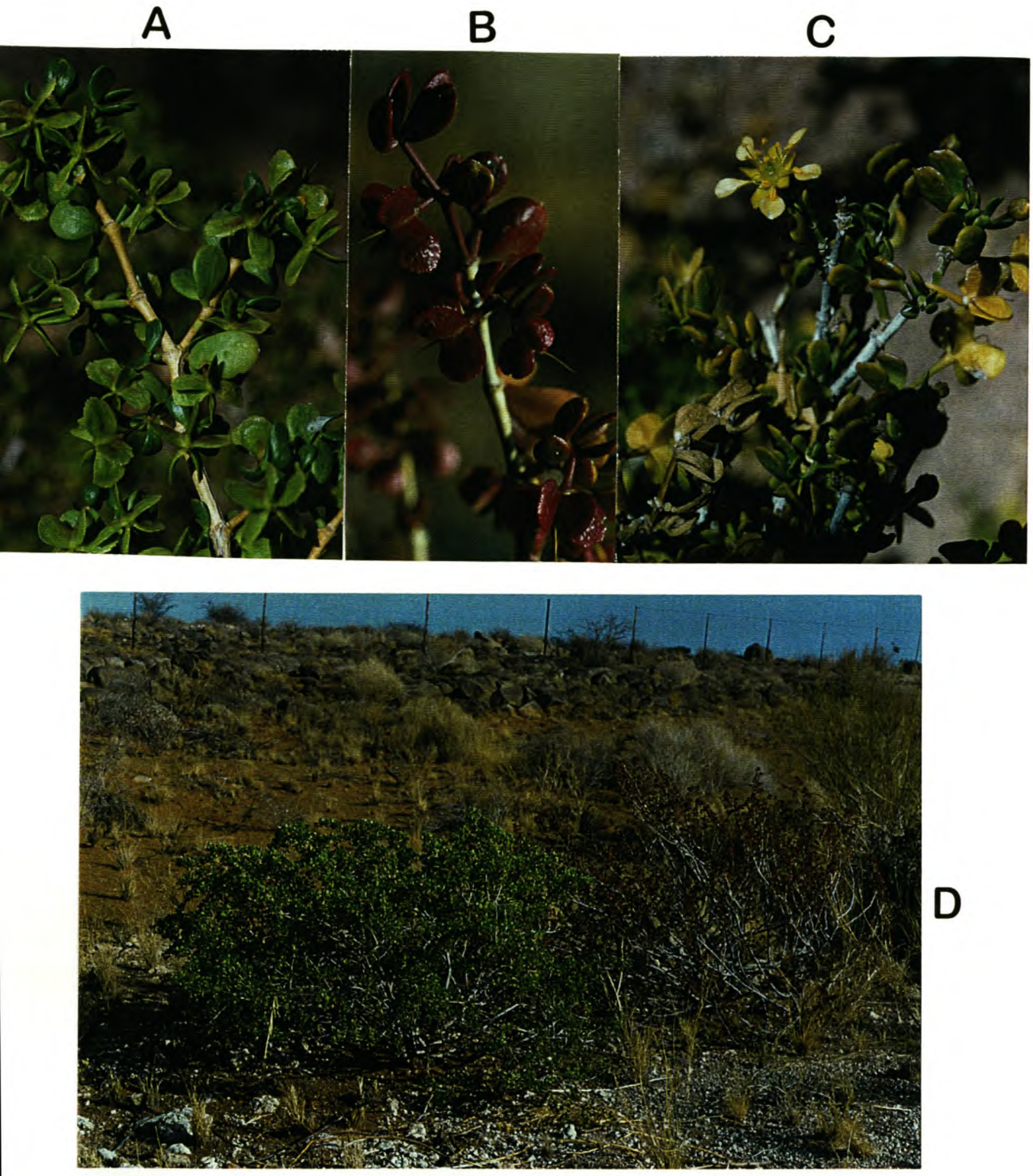


Figure 7.17.1. *Z. rigidum*. A and B, coloured fruits, *Van Zyl 4311*; C, flower, *Van Zyl 3760*; D, habit near Keimoes, *Van Zyl 4311*.

undulate, apex narrowly or widely retuse, tinted yellow, orange or burgundy, wider than long, 5–7 x 12–15 mm, breaking up in 5 compressed, reticulate-veined mericarps. *Seed* compressed pyriform, 1–3 per locule, 2.3–2.8 x 1.5–1.8 mm, brown, when immature attached by a long funicle, testa course, nearly transparent when wet and producing structured mucilage with short, spiral inclusions that seem to unravel at the apex (Figure 7.17.1).

Diagnostic features and affinities

Z. rigidum is distinguished by its prominently grooved young stems, by the droopy, bright coloured, 5-winged fruits usually with undulating wings (Figure 7.17.1.A—C), by its bifoliolate, sub-petiolate leaves with short petioles of 0.5—2.0 mm in length (Figure7.17.1.A—C) and by its simple staminal scales which have truncate, denticulate apices and which enfold the filaments alternately (Figure 7.18.1.F–H). *Z. rigidum* is allied to *Z. microcarpum* and *Z. longistipulatum* with regard to vegetative and floral morphology. All three species have prominent ventral grooves on young stems, simple staminal scales and widely-winged fruits. They are distinguished from each other by the length of their petioles and by the presence or absence of an indumentum. *Z. rigidum* has very short petioles (0.5—2 mm long) and lack an indumentum except on its ovary which is also sometimes glabrescent. Both *Z. microcarpum* and *Z. longistipulatum* have longer petioles (4–10 mm long) and are always densely or sparsely covered with white, two-armed trichomes. Table 7.4 summarizes the characters of the species in subsection *Alata.*
The specific epithet probably refers to the stiff or rigid stipules present at nodes.

Distribution and ecology

Z. rigidum has an extensive distribution in the southern part of Namibia with outlyer populations in the Bushmanland area of South Africa (Figure 7.17.2). In Namibia it occurs in vegetation classified as **Nama Karoo Biome** (Irish 1994), typified by chaemaephytic - hemicryptophytic co-dominance. Rainfall is primarily during summer months. The outlyer populations within South Africa also occur in vegetation classified as **Nama Karoo Biome** (Hoffman 1996). Here, over 80% of the area is covered by a lime-rich, weakly developed soil over rock. Notes on

herbarium sheets reflect this lime-rich substrate for *Z. rigidum* as well as the co-existence with grasses which is part of the typical vegetation for this Biome (Hoffman 1996). Populations of this species are also found on dolerite, shale, coarse loamy sand, quartz or granite outcrops, on hillsides, but mostly on grassy planes. Populations are large with many, scattered individuals over large areas including many young plants and seedlings. Grazing damage is negligible. Resprouting takes place from the woody, basal parts. Flowering and fruiting periods are during the rainy season in summer with a peak in February to May. Because of its large distribution area, many populations and high numbers within a population, this species is under no threat at present.

Common name: Skilpadbos.

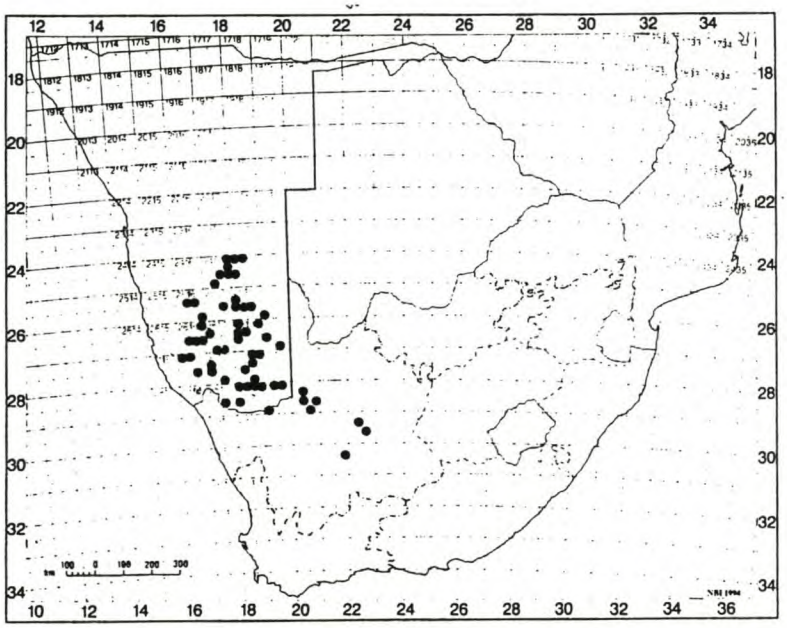


Figure 7.17.2. Geographical distribution of *Z. rigidum*.

Specimens examined

–2416 (Maltahohe): Rinnsal on Karoovlakte at Mariental (–DA), *Dinter 3060* (SAM).

–2417 (Mariental): W of Twilight, N of Mariental (–BB), *Van Zyl 3783* (NBG); Between Hardap and Komatsas (–BD), *Coetzee 15* (PRE, WIND); *Coetzee 10* (PRE, WIND); Groot Komatsas, Hardap (–BD), *Grobler 4* (WIND); 10 m from Mariental on Voogtsgrund (–CD), *Liebenberg 5139* (WIND); Dassiefontein: GIB 101(–DA), *Giess, Volk & Bleissner* 5594 (WIND); Mariental (–DA), *Volk 12230* (WIND); Farm Haribes: GIB 18/19 (–DA), *Volk 12312* (WIND); 20 km W of Mariental on road to

Maltahohe (–DB), *Germishuizen 2770* (PRE, WIND); Near offices at Hardap (DB), *Van Zyl 3782* (NBG).

–2418 (Stampriet): 16 m from Stampriet on road to Uhlenhorst (AA), *Van Vuuren & Giess 1164* (PRE, WIND); Campbellsdrei: REH 137 (–AB), *Giess 8348* (WIND); Auf Kalkplateau, E of Mariental (–CA), *Giess, Volk & Bleissner 5591* (PRE, WIND).

–2516 (Helmeringhausen): 20 km SW of Duwisib (–AD), *Van Zyl 3809* (NBG, PRE); *Giess 2037* (WIND); 1 km S of Duwisib (–BC), *Van Zyl 3808* (NBG); Goais: BET 13 (–DD), *Giess 8804* (WIND); 10 km N of Helmeringhausen (–DD), *Jurgens 22099* (PRE).

–2517 (Gibeon): Lichtenfels: KEE 10 (–DA), *Giess 8315* (WIND).

–2518 (Tses): Garichanab: GIB 67 (–AC), *Giess 8332* (WIND); Mukurob: KEE 14 (–CA), *Giess, Volk & Bleissner 6833* (WIND); *Van Zyl 3778* (NBG); Daberas Pforte, N of Keetmanshoop (–CB), *Van Zyl 3776* (NBG); Clara 180, N of Keetmanshoop (–DA), *Van Zyl 3775* (NBG).

–2519 (Koes): Koes: KEE 202 (–CC), *Giess & Wolf 10946* (WIND).

–2616 (Aus): Mooifontein: BET 50 (–BB), *Giess, Volk & Bleissner 5512* (WIND); 9 km W of Schakalskuppe (–CB), *Van Zyl 3861* (NBG, PRE); River N of Schakalskuppe (–DA), *Range 1696* (SAM); Kuibis (–DB*), Range 668* (BOL); Near Guibes, 34 km W of Goageb (–DB), *Van Zyl 3858* (NBG, PRE).

–2617 (Bethanie): Bucholzbrun 14, 12 km W of Goageb (–AC), *Van Zyl 3854* (NBG); Sandverhaar (–CD), *Pearson 4671* (BOL, SAM); 6 km E of Goageb (–CD), *Ward 9384* (PRE, WIND); *Ward 9380* (WIND); 20 km W of Seeheim (–DC), *Van Zyl 3848* (NBG); Seeheim (–DD), *Dinter 2939* (SAM).

–2618 (Keetmanshoop): 20 m from Keetmanshoop on road to Asab (–AA), *Tölken & Hardy 631* (WIND); Itzawisis: KEE 9 (–AA), *Giess, Volk & Bleissner 6884* (WIND); Keetmanshoop (–AC), Pearson 9283 (BOL); *Rauh 49110a* (WIND); Blaukehl Sud 142, NE of Keetmanshoop (–AD), *Van Zyl 3771* (NBG); Garinais: KEE 30 (–BB), *Giess 8372* (WIND); Kokerboomwoud, 12km NE of Keetmanshoop (–CA), *Van Zyl 3769* (NBG); W of Gellap-Ost, 15 km NW of Keetmanshoop (–CA), *Maggs 98* (WIND); *Maggs 120* (WIND); Keetmanshoop (–CA), *Boss TM 36000* (PRE); 9 m NE of Spitskop on Keetmans to Koes road (–CA), *Codd 5900* (WIND).

–2619 (Aroab): Gross Aub: KEE 44 (–CA), *Giess 8367* (WIND); 3 m N of Aroab (–DC), *Acocks 18097* (PRE).

–2716 (Witputz): Diamandgebied 1: W side of Tsausberg (–AA), *Wendt A/9* (WIND); *Wendt 1/6* (WIND); *Wendt C/18* (WIND); *Wendt 19/3* (WIND); *Wendt B/11* (WIND); Arutal: LU 25 (–AB), *Giess, Volk & Bleissner 5308* (WIND); *Merxmüller & Giess 2373* (WIND); *Van Zyl 3890* (NBG); Witputz Nord: LU 22 (–DA), *De Winter & Giess 6299* (WIND); Rosh Pinah - Witputz (–DA), *Evrard 9192* (PRE); Arimas, N of Rosh Pinah (–DB), *Van Zyl 4401* (NBG).

–2717 (Chamaites): Huns: BET 106, on Schwarzkalk-Berghang (–AC), *Giess 14600* (WIND); Uitsig 82, NE of Rosh Pinah (–CA), *Oliver & Muller 6399* (PRE); State area, 3 km S of Uitsig (–CA), *Giess 14339* (WIND); Fish River Canyon (–DA), *Hall 520* (NBG); *Van Zyl 3840a* (NBG); W of house on Kario (–DB), *Craven 4091* (WIND); Kwaggasnek, SE of Ai-Aais (–DC), *Van Zyl 3836* (BOL, NBG, WIND); 6 km E of Ai-Ais on R97 (–DC), *Van Zyl 4360* (NBG).

–2718 (Grunau): Noachabeb, Great Karasberg (–BA), *Örtendahl 412* (PRE); Pietersкloof: KEE 370 (–BB), *Giess & Muller 11942* (WIND); Between Dassiefontein and Noachabeb (–BC), *Pearson 8566* (BOL); Genadendal, S end of Great Karasberg (–BC), *Oliver & Steenkamp 6308* (PRE); 73 m from Keetmanshoop on road to Karasburg (–BC), *Gerstner 6399* (NBG, PRE); Klein Karas (–CA), *Dinter 3217* (SAM); 19 m N of Grunau (–CB), *Wilman 289* (BOL); Kanus siding, N of Karasburg (–DC), *Van Zyl 3765* (NBG).

–2816 (Oranjemund): River N of Schakalskuppe (–BA), *Range 1696* (SAM).

–2817 (Vioolsdrif): Opposite Oena Mine on N side of Orange River (–AA), *Van Zyl 4342* NBG, PRE); Blokwerf, N side of Orange River (–AA), *Van Zyl 4380, 4381, 4382* (NBG); N of Aussenkehr and S of Gamkab confluence with the Orange River (–AD), *Van Zyl 4374* (NBG, PRE); Kahams area, E of Stinkfonteinberge (–CA), *Oliver, Tölken & Venter 662* (NBG, PRE); 26 km from Eksteensfontein on road to Mount Stewart (–CB), *Germishuizen 4709* (PRE); 20 km from Vioolsdrif on road to Octa (–DA), *Van Wyk 6583* (PRE); 6 M S of Vioolsdrif (–DC), *Thorne s.n.* (SAM 51587).

–2818 (Warmbad): Norachas: WAR 14 (–AA), *Giess, Volk & Bleissner 6913* (WIND); NE of Karuchas in Bondelswartsgebied (–AB), *Van Zyl 3762* (NBG); *Van Zyl 3760* (NBG, PRE, WIND); 25 - 40 km N of Warmbad (–BA), *Pearson 4365* (BOL); Naruchas: WAR 49 (–BB), *Giess 14494* (PRE, WIND); Witputz: WAR 258 (–CA), *Giess, Volk & Bleissner 6950* (PRE, WIND).

–2819 (Ariamsvlei): Kokerboom Stasie (–AB), *Pole-Evans 19370* (WIND); 55 M E of Karasburg (–BA), *Hardy 1958* (WIND); Keimas: WAR 99 (–CC), *Giess & Muller 12159* (PRE, WIND).

–2820 (Kakamas): Riemvastmaak, Upington district (–AD), *Barnard s.n. (SAM 36115*); Rooipad, part 1 (–CB), *Leistner 3328* (WIND); Augrabies National Park, 5 M S of camp (–CB), *Leistner 3358* (WIND); Augrabies National Park, N of river near entrance to Park (–CB), *Werger 356, 1478* (PRE); In sand at Augrabies Falls (–CB), *Barker 8301* (NBG); Dyason's Klip, between Upington and Keimoes (–DB), *Glower 13348* (BOL); N bank of Orange River, 10 m from Kakamas (–DC), *Lewis 204* (SAM); 9 M ENE of Kakamas (–DC), Leistner & Joynt 2814 (PRE); 11 km E of Kakamas on road to Keimoes (–DC), *Davidse & Loxton 6152* (PRE); Letterkop at Kakamas (–DC), *Wasserfall 1057a* (PRE).

–2821 (Upington): Keimoes, next to R27 (–CC), *Van Zyl 4311* (NBG, PRE, S, WIND).

–2919 (Pofadder): Top of Pellaberg, SE of Charles Pass (–AA), *Van Jaarsveld & Kritzinger 8051* (NBG); S of Pella on road to Pelladrift (–AA), *Van Zyl 4316* (NBG).

–2922 (Prieska): 3 M S of Koegas on way to Draghoender (Marydale) (–AD), *Werger 135* (PRE); 13 M E of Draghoender Stasie (–AD), *Codd 1231* (PRE); Near Abrahamsdam (–BA), Mostert 1296 (PRE); Enkelwilger, Prieska (–DA), *Penderies 3* (NBG); Kalkveld, Prieska (–DB), *Roux 38* (PRE).

–3021 (Vanwyksvlei): Dolerite hill overlooking Vanwyksvlei (–BD), *Acocks 1787* (BOL, PRE).

No presice or unknown locality: Between Ausis and Khuias on Huibplateau, Namibia, *Schenck 212* (PRE); Narubis - Anengoas, Namibia, *Ortendahl 556* (BOL); W of Ganus, *Pearson 4311* (BOL); Lager am Fischflusscanyon, *Walter 2301* (WIND); *Dinter 1984* (SAM); *Range 668* (SAM); Stofbakkies, near Prieska, *Acocks 1329* (PRE); Prieska, *Bryant 265, 1186* (PRE); 30 M W of Ladismith, *Compton 7496* (NBG); Between Brandvlei and Kenhardt, *Leipoldt s.n.* (BOL 49468); District Hopetown, *Mostert 1270* (PRE).

7.18 Zygophyllum longistipulatum *Schinz* Verhandlungen des Botanischen Vereins..... 29 : 56-57 (1888); Huysst.: 63 (1937); A.Schreib.: 90 (1963); A.Schreib. in Merxm.: 17 (1966). Locality - Namibia: Kuibes, no specimen mentioned. TYPE - Namibia: Kuibes, *Schinz 1028*, (Z! neo., designated here).

Zygophyllum incanum *Schinz,* 190 (1894); Huysst.: 63 (1937); A.Schreib. 90 (1963); A.Schreib. in Merxm.: 17 (1966). TYPE - Namibia: Kuibes, *Schinz 1028* (Z! lecto, designated here); Aus, *Schenck 187* (Z!, syn.).

Although Schinz (1888) mentioned the locality as Kuibes, he failed to mention a specimen in his original description of this species. When he described *Z. incanum* in Bulletin de l'Herbier Boissier 2 : 190 (1894), now considered a synonym of *Z. longistipulatum,* he mentioned the same locality, Kuibes, quoting the specimen Schinz *1028.* Therefore the lectotype of *Z. incanum* was chosen to represent *Z. longistipulatum* also.

Spreading, many stemmed shrub, reaching a height of 1.0 m and a diameter of 1.0 m, all parts hairy with white, appressed, two-armed trichomes. *Stems:* old stems leafless, bark dark gray, finely cracked, nodes swollen; younger stems greenish or cream coloured, leafy, with a prominent ventral groove. *Leaves* opposite, petiolate, bifoliolate, dark green or gray, often burgundy edged or completely burgundy coloured; leaflets articulate, obovate, apex rounded or acute, mucronate, base rounded or cuneate, 5–9 x 3–4 mm; rachis apex filamentous, minute; petiole articulate, obovate, flat, adaxially grooved, 4—10 mm long; stipules subulate, white, base thickened, upper part stiff, apex acuminate, on ventral side alternately two (free) or one (fused) and two on dorsal side, 2–3 x 0.5 mm, base semi-permanent. *Flowers* solitary, axillary. *Pedicel* 2—4 mm long, elongating in fruit to 10 mm. *Sepals* 5, ovate or obovate, articulate, membranous margined, outer ones slightly succulent, cucullate, 2–5 x 1.5–2 mm. *Petals* 5, spathulate, apex round, base with a long claw, white, light yellow or peach coloured, 5–7 x 1.5–2.5 mm. *Nectar disc* fleshy, smooth, alternately 5-angled and 5-lobed, sloping slightly towards its periphery and displaying 10 small lobes, orientated downwards at its base. *Stamens* 10; filaments terete, 4—6 mm long; staminal scales 10, simple, nearly transparent, alternately with different orientation, apex of antipetalous scale enfolding filament (Figure 7.18.1.G), antisepalous scale open at apex (Figure 7.18.1.F), oblong, apex truncate, denticulate, lateral margins entire, base rounded,

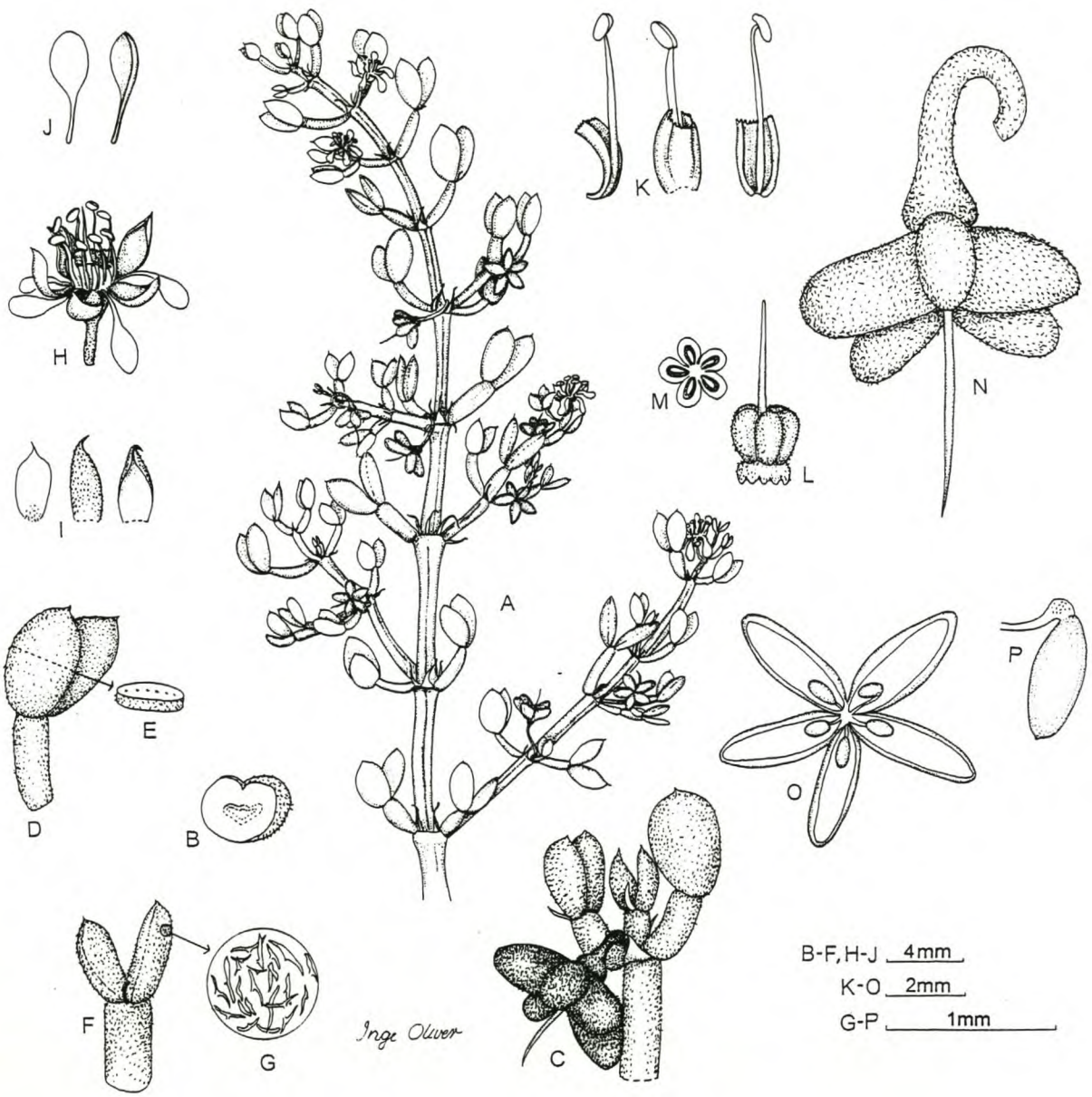


Figure 7.18.1. *Z. longicapsulare, Van Zyl 4481*. A, branch with flowers, fruit and leaves, life-size; B, cross section of young stem; C, twig with young leaves and a fruit; D, side-view of leaf; E, cross section of leaflet; F, abaxial view of leaf; G, two-armed hairs; H, open flower; I, sepals; J, petals; K, side-view, ventral-view and dorsal-view of staminal scale; L, ovary; M, cross section of ovary; N, drooping fruit; O, cross section of fruit; P, immature seed with funicle.

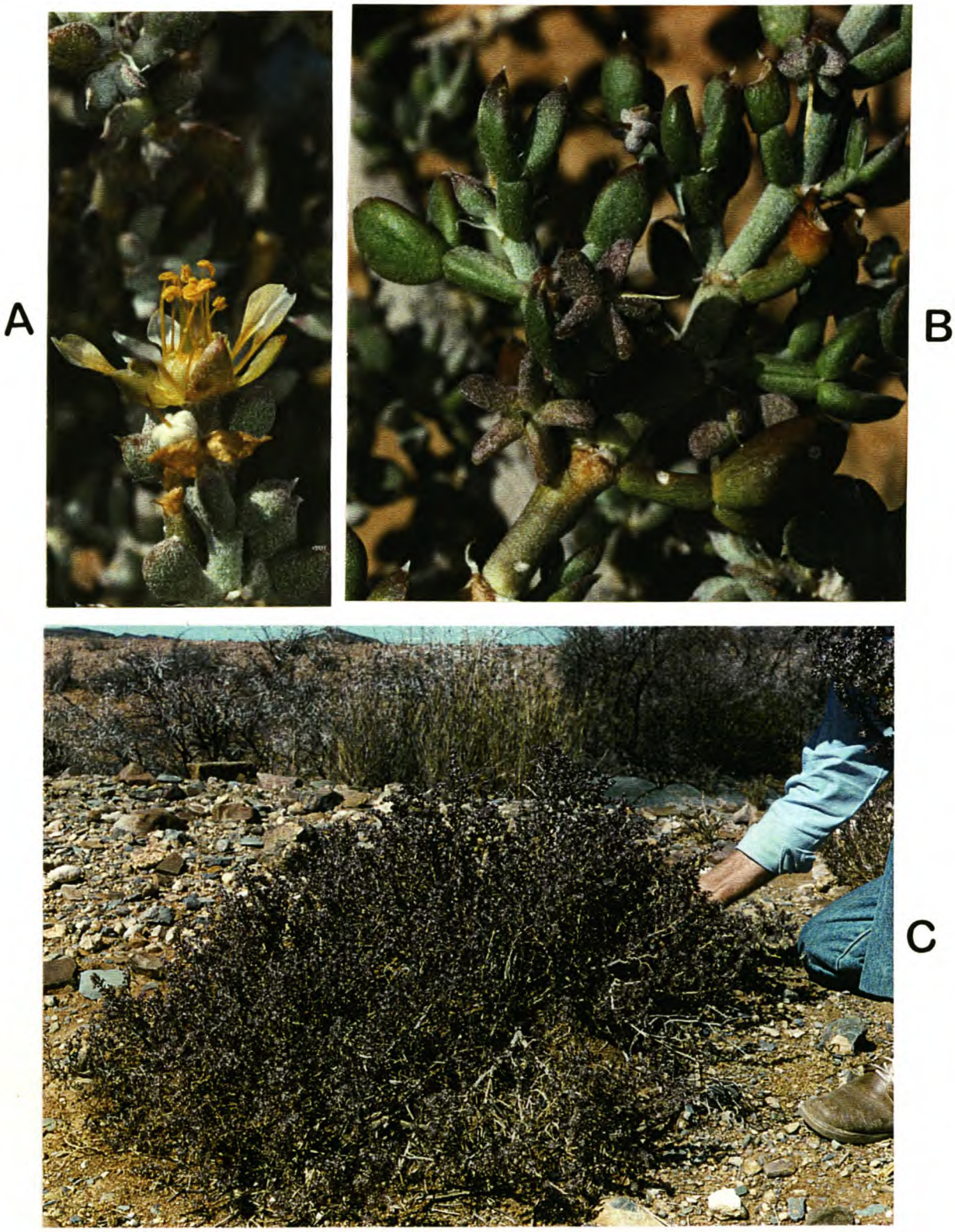


Figure 7.18.2. *Z. longistipulatum, Van Zyl 4481*. A, twig with flower, displaying white indumentum; B, twig with leaves and fruit, displaying white indumentum; C, habit on Arimas in the south of Namibia.

1.5–2.5 x 1.5–2.0 mm, ± ½ or 1/3 the length of the filament. *Ovary* obovate, 5-parted, always wider than long, densely white haired, apex retuse; style terete; stigma simple. *Fruit* a drooping, septicidal schizocarp, 5-winged, wings always wider than long, straight, never undulate (propellate), burgundy tinted or completely burgundy coloured, 2–3 x 7.5 mm in size, breaking up in five, slightly reticulate-veined mericarps. *Seed* compressed pyriform, 1 per locule, 1.5–2.0 x 1.0–1.5 mm, brown, when immature attached by a long funicle, testa grainy, nearly transparent when wet and producing structured mucilage with short, spiral inclusions that seem to unravel at the apex (Figure 7.18.1).

Diagnostic features and affinities

Z. longistipulatum is distinguished by its small, droopy, wider than long, 5-winged fruits (Figure 7.18.2.B) with straight wings and by the presence of white, two-armed hairs on all its parts (Figures 7.18.1.O; 7.18.2.A—B). It is allied to *Z. rigidum* and *Z. microcarpum*. All three species have a similar floral morphology displaying simple staminal scales, truncate and denticulate at the apex and enfolding alternate filaments (Figure 7.18.1.F—H), similar spathulate petals and nectar discs. They differ with regard to fruit and leaf morphology. All three species have winged fruits, but the wings on the fruits of *Z. rigidum* and *Z. microcarpum* are usually undulate, those of *Z. longistipulatum* are always straight. All three species have petiolate, bifoliolate leaves but the petioles of *Z. rigidum* are very short, from 0.5—2 mm in length, whereas the petioles of *Z. longistipulatum* and *Z. microcarpum* are longer, from 4—10 mm in length. The specific epithet refers to the rather long stipules present on its stems. Table 7.4 summarizes the characters of the species in § *Alata*, subsection *Alata*.

Distribution and ecology

Z. longistipulatum has a limited distribution in the central southern part of Namibia, from Maltahohe in the north to as far south as the Hunsberge near the Orange River (Figure 7.18.3). It occurs in a vegetation classified as **Nama Karoo Biome** (Irish 1994), characterized by chamaephytic - hemicryptophytic codominance. Rain

occurs primarily during summer months. Populations of this species are found on limestone-rich substrates, in dry water courses or flat valley floors or on loose conglomerates. Populations are small and individuals are scattered. During periods of drought or during the hottest months of the year this species seems not to shed its leaves, but becomes prominently bronzed or burgundy coloured (Figure 7.18.2.C). Grazing damage is negligible. Young plants or seedlings are rare. Resprouting occurs from the woody, basal parts. Flowering and fruiting periods are throughout the year. Because of its small distribution, few populations and low numbers within a population, this species is considered vulnerable.

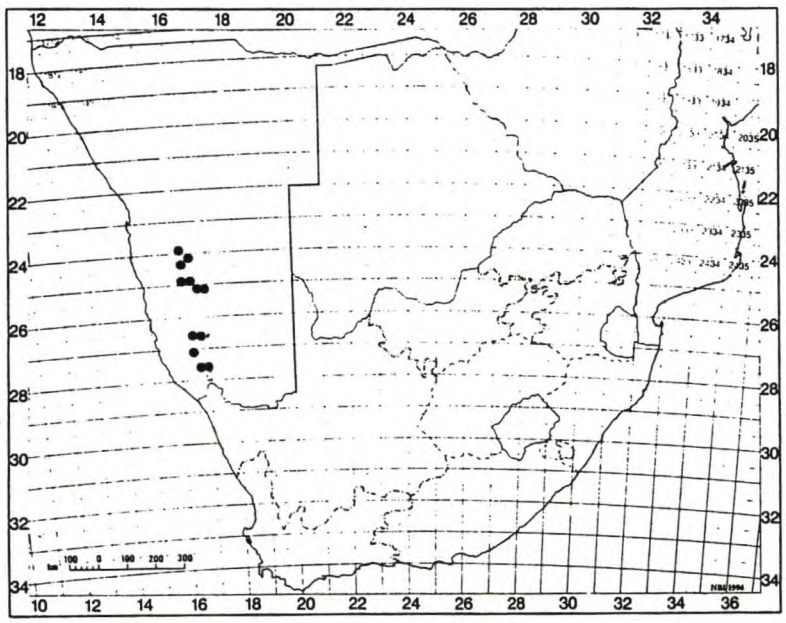


Figure 7.18.3. Geographical distribution of *Z. longistipulatum.*

Specimens examined

–2316 (Nauchas): 30 km S of Solitaire on road to Maltahohe (–CC), *Craven 3468* (WIND).

–2416 (Maltahohe): Naukloof Mountains at Bullspoort (–AB), *Rodin 2828 & Strey 2078* (BOL); Lemoenputs (–AC), *Muller & Tilson 911* (WIND); Maltahohe (–CC), *Cronje 4* (WIND); Summit of limestone ridge, Zarisberg on farm Uitkoms (–CD), *Logan 26* (WIND).

–2516 (Helmeringhausen): Kleinfontein Nord, 48 km S of Maltahohe (–BA/BB), *Van Zyl 3802* (NBG, PRE); *Van Zyl 3806* (NBG, PRE).

–2616 (Aus): Aus (–CB), *Schenck 187* (Z); Farm Plateau (–CB), *Walter 148* (WIND); Mesklippe, Aus (–CB), *Dinter 3559* (B, BOL); *Krausel & Wiss 2014* (WIND); *Wiss 2022* (WIND); Farm Aar: LU 16, Aarrivier (–DA), *Wendt 161* (WIND); *Wiss 2537* (WIND); Schakalskuppe, 50 km W of Goageb (–

DA), *Van Zyl 3859* (NBG, PRE); *Dinter 1168* (SAM); *Dinter 4183* (BM, SAM); *Dinter 4182* (B); Kuibes, *Schinz 1028* (–DB).

–2716 (Witputz): Pockenbank, N of Witputz (–AB), *Range 1513* (BOL, SAM); Arutal: LU 25, 28 S of Aus (–AB), *Van Zyl 3884* (NBG, PRE); *Van Zyl 3887* (NBG); *Van Zyl 3889* (NBG); Zebrafontein: LU 87, 10 m S of Witputz (–DA), *Giess, Volk & Bleissner 5347* (PRE, WIND); Arimas: LU 83, N of Rosh Pinah (–DB), *Van Zyl 4405* (NBG, PRE); *Van Zyl 4352* (B, BOL, NBG, PRE, WIND); *Van Zyl 4481* (NBG, PRE); *Van Berkel 545/W24* (NBG, WIND); Kolke: LU 84 (–DB), *Giess 13830* (PRE, WIND); *Rusch & Wiss in Merxmüller 2522* (WIND).

–2717 (Chamaites): Huns Mountains, 30 m SE of Witputz (–AC/CC), *McDonald 225* (BM).

Unknown locality: Gabisch Pforte, *Dinter 2204* (SAM).

§ Cinerea *Huysst., Morphologisch-systemat Studien über die Gattung* Zygophyllum……: 62 (1937).

Type species: *Z. cinereum* Schinz, in synonymy with *Z. longicapsulare* Schinz.

Diagnostic features

Indumentum of silver-white, two-armed trichomes present

Young stems with a ventral groove

Leaves opposite, petiolate, bifoliolate, leaflets obovate or orbiculate

Petals narrowly obovate or spathulate, white, creamish or flushed with pink, with a weak fold along its length

Nectar disc smooth, 10-angled, flat on top, with 10 small lobes situated at base of disc and orientated downwards

Staminal scales simple, apex acute, upper margins lacerate

Ovary conical, globulate, short-styled

Fresh fruit succulent, cylindrical or spherical,

dry fruit brown, 5-angled, wrinkled, exocarp disintegrating and exposing hard endocarp containing the seeds

Van Huyssteen (1937) established § *Cinerea* as a monotypic section containing *Z. cinereum* Schinz, which was placed into synonymy with *Z. longicapsulare* Schinz (Schreiber 1963). A later addition to § *Cinerea* is *Z. giessii* Merxm. & Schreib. Table 7.5 summarizes the characters of the species in § *Cinerea.*

Key to species in § *Cinerea*:

1a Leaflets with apex rounded, young stems with a dense white, indumentum of two-armed trichomes, older stems less hairy, stipules triangular, reflexed, with a fleshy, brown base, 1—1.5 mm long.....*Z. longicapsulare*

1b Leaflets with apex acute, stems nude or with a sparse indumentum of two-armed trichomes, stipules subulate, silver-white, stiff, tip slightly curly, 3—6 mm long. .....*Z. giessii*

Table 7.5. Characters of the species in § *Cinerea*

Z. LONGICAPSULARE	**Z. GIESSII**
succulent shrublet, 0.4–0.7 x 1.0 m	non-succulent shrublet 0.3 x 0.6 m
stems densely white-haired	stems sparsely hairy or glabrous
leaflets orbiculate or obovate, green, 7–15 x 5–12 mm	leaflets obovate, apex acute, silvery-white, 6–8 x 2–3 mm
petals white, rarely cream, obovate, 7–9 x 0.5–1.5 mm	petals white or flushed with pink, obovate, 4.0–5.0 x 1.0–1.3 mm
nectar disc smooth, 10-lobed, lobes orientated downward	nectar disc smooth, 10-lobed, lobes orientated downward
staminal scales simple, 2.5–4.0 x 1.0–1.5 mm	staminal scales simple, 1.5 x 1.0–1.5 mm
ovary conical, globulate	ovary conical, globulate
fresh fruit succulent, cylindrical, dry fruit 5-angled, wrinkled, 8–14 x 4–7 mm, breaking up in 5 mericarps	fresh fruit succulent, cylindrical, dry fruit somewhat 5-lobed, wrinkled, 7–10 x 3–4 mm, breaking up in 5 mericarps
seeds pyriform, mericarps 5—9-seeded	seeds pyriform, mericarps 5—15-seeded

7.19 Zygophyllum longicapsulare *Schinz* in Verhandlungen des Botanischen Vereins.....29: 55 (1888); Huysst.: 76 (1937); A.Schreib.: 86 (1963); A.Schreib. in Merxm.: 16 (1966). Locality - Namibia: Tschirubgebirge, district Luderitz-Sud, but no specimen is mentioned. TYPE - Namibia: Zwischen Angra Pequena and Aus, *Schinz 1031* (Z, neo!, designated here); Zwischen Angra Pequena and Aus, *Herman 44* (Z!). Although Schinz (1888) mentioned the locality Tschirubgebirge, Luderitz-Sud, he failed to mention a collector or collection in his original description of this species. When he later described *Z. cinereum* in Bulletin de l'Herbier Boissier 2 : 189 (1894), now considered a synonym of *Z. longicapsulare*, he mentioned a **different locality** as well as a collector and number. In my opinion these two taxa are conspecific and therefore the lectotype of *Z. cinereum* was chosen to represent this taxon also.

Zygophyllum cinereum *Schinz*: 189–190 (1894); Huysst.: 62 (1937). TYPE - Namibia: Zwischen Angra Pequena and Aus, *Schinz 1031* (Z!, lecto., designated here), Zwischen Angra Pequena and Aus, *Herman 44 (*Z!, syn.).

Zygophyllum campanulatum *Dinter ex Range*: 247 (1934); *Dinter 6393*, Pomona, nom. nud.

In her key on p. 84, Van Huyssteen (1937) distinguished between *Z. longicapsulare* (with white stipules) and *Z. cinereum* (with brown stipules), although it is uncertain whether she saw their types. She created a monotypic § *Cinerea* because she regarded *Z. longicapsulare* as insuffiently known (p. 76). Schreiber (1963) although not finding the type of *Z. longicapsulare*, regarded *Z. cinereum* as a synonym of *Z. longicapsulare*. According to the descriptions of *Z. longicapsulare* Schinz (1888) and *Z. cinereum* Schinz (1894), I agree that these two species are conspecific.

Shrub with spreading branches and a many-stemmed woody base, reaching a height of 0.4 (–0.7) m and a diameter of 1 m. *Stems*: old stems gray, leafless, nodes prominent; young stems covered with dense, adpressed, white, two-armed trichomes, with a prominent, brown groove on ventral side. *Leaves* opposite, bifoliolate, petiolate, articulate, glabrous or sparsely clothed with caducous, two-armed trichomes; petiole adaxially grooved, 3—7 mm long; rachis apex filamentous, caducous; leaflets orbiculate or obovate, green, conduplicate,

succulent, apex round, base narrowed or cuneate, 7–15 x 5–12 mm; stipules triangular, brown, reflexed and base thickened, two on ventral and two on dorsal side of stems, caducous, 1.0 x 1.5 mm. *Flowers* solitary or rarely 2 together, axillary. *Pedicel* 2—4 mm long. *Sepals* 5, ovate or elliptic, succulent, some cucullate and keeled, membranous margined, 4–8 x 1.5–3.0 mm. *Petals* 5, oblanceolate, with a weak fold along its length, apex acute or rounded, base with a long claw, white or rarely cream coloured, 7–9 x 0.5–1.5 mm. *Nectar disc* fleshy, smooth, 10-lobed, lobes orientated downwards, the disc sloping gradually towards its periphery. *Stamens* 10; filaments nearly straight, terete, 6—7 mm long; staminal scales 10, simple, elliptic or ovate, margins lacerate, 2.5–4.0 x 1.0–1.5 mm, ± 1/3 the length of the filament. *Ovary* conical, vaguely 5-lobed, globulate; style short, terete; stigma simple. *Fruit* a septicidal, pendulous schizocarp; succulent when fresh, yellowish-green or brown, cylindrical, spherical or oblong, sometimes with faint sutures visible, 8–14 x 4–7 mm; 5-angled or 5-lobed when dry, exocarp wrinkled, eventually breaking up in five mericarps that stay apically attached and partially encapsulated by the wrinkled exocarp, resembling a half open umbrella hanging upside down. *Seed* pyriform, 5—9 per locule, 2 x 1 mm, light-brown, when immature attached by a long funicle, testa grainy, becoming transparent when wet and producing a thick layer of structured mucilage with short, spiral inclusions that seem to unravel at the apex (Figure 7.19.1).

Diagnostic characters and affinities

Z. longicapsulare is distinguished by the dense white, two-armed trichomes and the brown, ventral groove found on its young stems (Figure 7.19.1.A), by its simple staminal scales with lacerated margins and by its succulent, cylindrical or spherical fruits (Figure 7.19.1.B—C). It is allied to *Z. giessii,* which have a similar but more sparse indumentum as well as similar floral and fruit morphology. These two species are distinguished by their different leaves and stipules. The leaflets of *Z. giessii* are greyish, obovate, with an acute apex and those of *Z. longicapsulare* are green, orbicular or obovate with a rounded apex. The stipules of *Z. giessii* are subulate, white, stiff, with a undulate, attenuate apex and are 3–6 x 1 mm in size, whereas those of *Z. longicapsulare* are triangular, brownish and 1 x 1.5 mm in size.

B

C

D

F

Figure 7.19.1. *Z. longicapsulare*. A, twigs displaying white flowers, conduplicate leaflets and brown, grooved ventral side of young stems, *Van Zyl 4570*; B, yellowish-green, succulent fruits, *Van Zyl 4570*; C, brown, succulent fruits, *Van Zyl 3885;* D, dry, drooping fruits, partially separated in separate mericarps, *Van Zyl 4570*; E, old trunk showing evidence of repeated sprouting, *Van Zyl 4570*; F, habitat in Helskloof, Richtersveld, *Van Zyl 4497*.

The fruits and leaves of *Z. longicapsulare* resemble those of *Z. applanatum,* but these two species are distinguished from each other by the lack of indumentum as well as the divided staminal scales of *Z. applanatum*. Table 7.5 summarizes the characters of the species in § *Cinerea.*
The epithet *longicapsulare* refers to the fruit of this species which, although not very long, certainly longer than wide.

Distribution and ecology

Z. longicapsulare is limited to the south-western parts of Namibia where it is found from the Tsaukhaib Diamond area, Sossusvlei in the north to Cornellskop and Helskloof in the Richtersveld in the south (Figure 7.19.2). It occurs in a vegetation classified as **Desert Biome** with a very low, primarily summer rainfall which could be substituted with coastal fogs, **Succulent Karoo Biome** with a low winter rainfall followed by dry, hot summers and **Nama Karoo Biome** with a low summer rainfall (Irish, 1994). Large populations as well as scattered individuals occur on sloping, rocky substrates of granite, gneiss, shale and dolomite and on sandy valley floors or plains. The bifoliolate leaflets of *Z. longicapsulare* are borne in a conduplicate manner for protection against excessive insolation and form neat and orderly patterns. Flowering occurs throughout the year with a peak during August. Flowers are probably pollinated by bees and ants. Grazing damage is negligible. As with other *Zygophyllum species* with succulent fruits, several months elapse between flowering and maturation of fruits and seeds. Visits to Cornellskop in the Richtersveld during different months of the year confirmed that the flowering period is from July to September. Mature, dry fruits with seeds inside the mericarps, are present on individuals in December (Figure 7.19.1.D). A December or mid-summer visit to Cornellskop showed that a few leaves remained on *Z. longicapsulare*, whereas *Z. cordifolium, Z. shreiberanum* and *Z. patenticaule,* co-existing there, were completely leafless and that *Z. pterocaule* lost none of its leaves. *Z. longicapsulare* is perfectly adapted to harsh, desert conditions. Individuals of this species survive for many years and many individuals with old, thick, gnarled rootstocks, from where repeated sprouting occurs, were seen (Figure 7.19.1.E). Because of the large size of most populations and its extensive distribution range, the absence of grazing and

its many adaptations to arid conditions, this species seems to be under no threat at present.

Common name: Volstruisbos.

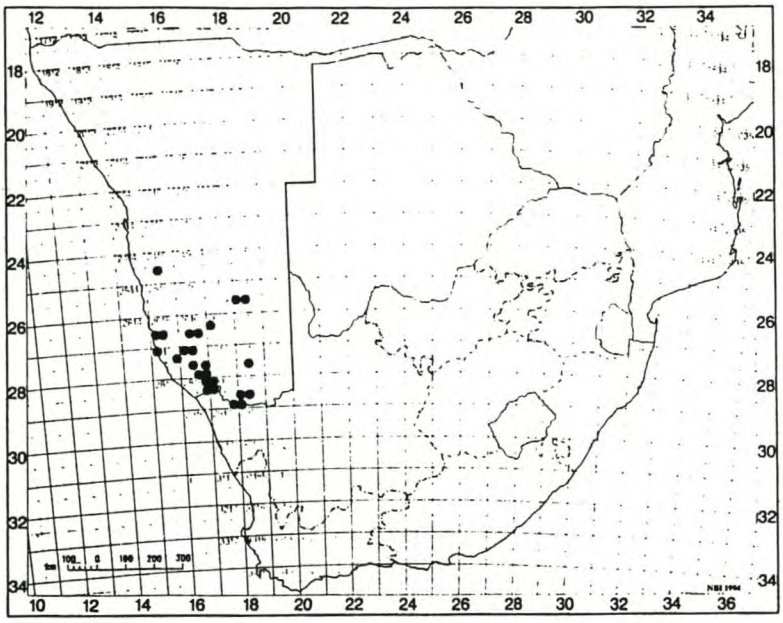


Figure 7.19.2. Geographical distribution of *Z. longicapsulare.*

Specimens examined

–2415 (Sossusvlei): W aspects of Tsaukhaib Diamond area (–CB), *Hardy & Venter 4478* (WIND).

–2518 (Tses): Mountain ridges at Mukorob: KEE 14 (–CA), *Giess, Volk & Bleissner 6834* (PRE, WIND); Limestone flats near Daberas Pforte 15, N of Keetmanshoop (–CB), *Van Zyl 3777* (NBG).

–2615 (Luderitz): Angra Pequena (–CA), *Galpin & Pearson 7442* (SAM); On beach at S point of lagoon, Luderitz (–CA), *Giess & Van Vuuren 675* (PRE, WIND); Redford Bay, Luderitz (–CA), *Giess & Van Vuuren 699* (PRE, WIND); Luderitz (–CA), *Range 496* (BOL, SAM); *Lavranos & Pehleemann* 19649 (WIND); On second lagoon, Luderitz (–CA), *Muller & Jankowitz 299* (WIND); Diamantberg, Luderitz (–CA), *Metz s.n.* (WIND 15915); Between turn off to Griffiths Bay and Grossebuch (–CA), *Van Zyl 3877* (NBG); Nautilus Nordlich (–CA), *Merxmüller & Giess 3078* (WIND); At Kovis mountains, 20 km E of Luderitz (–CB), *De Winter & Hardy 7909* (WIND); Sandy/stony desert plains near Grillenthal (–CD), *Van Zyl 3873* (NBG, WIND); Haalenberg (–CB), *Merxmüller & Giess 3117* (PRE, WIND); On the mountain at Haalenberg (–CB), *Leippert 4092* (WIND).

–2616 (Aus): Quartsite hill near Aus (–CB), *Pearson 8034* (BOL, SAM); On limestone at Augustfelde: LU 42 (–CB), *Merxmüller & Giess 28269* (WIND); On limestone banks at Kubub: LU 15 (–CB), *Giess, Volk & Bleissner 5302* (WIND); Jakalskuppe (–DA), Dinter 1157 (SAM); Stoney flats near Guibes (–DB), *Van Zyl 3857* (NBG, PRE, WIND).

–2617 (Bethanie): Bucholzbrun 14, W of Goageb (–AC), *Van Zyl 3852* (NBG, PRE, S, WIND).
–2715 (Bogenfels): Pomona (–AA), *Dinter 4058* (BOL, PRE); *Dinter 6393* (BOL, NBG, PRE, SAM); Sperrgebiet, Heioab (–BD), *Oliver 10203* (NBG).
–2716 (Witputz): SW slopes of Tsausberg, Diamantgebiet 1 (–AA), *Wendt B/12* (WIND); Arutal 25, S of Aus (–AB), *Van Zyl 3885* (NBG, WIND); Flats near the beacon on Aurus Mountains (–CB), *Oliver 10162* (NBG); Dolomitic plains at Kolke (–DB), *Van Zyl 4350* (NBG, WIND); Arimas/Kolke, N of Rosh Pinah (–DB*), Van Zyl 4402* (NBG, WIND); Farm Spitskop, S of Witputz (–DC), *Leippert 4190* (WIND); Gneiss koppe at Namuskluft (–DD), *Logan s.n.* (WIND 16013).
–2718 (Grunau): Limestone flats at Grabwater (–CB), *Dinter 5050* (PRE, NBG, SAM).
–2816 (Oranjemund): On shale of lower foothills NW of Lorelei Kupfermine (–BB), *Giess, Volk & Bleissner 5434* (WIND); SE slopes of Cornellskop (–BD*), Van Zyl 4137* (NBG, WIND); *Van Zyl 4065* (NBG); *Van Zyl 4570* (NBG); Numees experimental site (–BD), *Jurgens 9295* (NBG); N and E shale slopes in Helskloof (–BD), *Van Zyl 4497* (NBG, PRE).
–2817 (Vioolsdrif): Between Dabimub and Boom Rivers along Orange River (–AA), *Van Zyl 4332* (NBG); Blokkwerf on N side of Orange River (–AA), *Van Zyl 4378* (NBG); 15 km E of Helskloof (–AC), *Williamson 3029* (BOL); Flats near Bleskop (–DD), *Le Roux 2881* (NBG).
–2818 (Warmbad): Sperlingsputs 281 (–CA), *Jancowitz 195/790* (WIND); Rocky river bank on Chwarzeck: WAR 130 (–CB), *Giess & Muller 12236* (PRE, WIND); Near Henkries, between Steinkopf and Orange River (-CC), *Phillips 1582* (SAM).

7.20 **Zygophyllum giessii** *Merxm. & A.Schreib.* in Mitteilungen aus dem Botanischen Staatssammlung München: 2: 449 (1974). TYPE - Namibia: Loam flats on Farm Arimas, district Luderitz, *Merxmüller & Giess 28888* (M, holo., K, MO, PRE!, WIND!).

Shrublet with a woody base from where spreading or procumbent branches develop, reaching a height of 0.3 m and a diameter of 0.6 m; branches partially whither away during the dry season; all young parts covered with white, appressed, two-armed, trichomes, older parts sparsely hairy or glabrous. *Stems*: old stems nude, rough, gray or cream coloured, sometimes with peeling bark; younger stems smooth, densely leafy, with a prominent ventral groove. *Leaves* secund, opposite, bifoliolate, petiolate, articulate, glabrous or with sparse, two-armed hairs, hairs caducous, petiole adaxially grooved, 4–6 mm long; rachis apex filamentous, white, 2—5 mm long; leaflets asymmetrical, glaucous, obovate, conduplicate, succulent, when immature white membrane-margined, apex acute, base narrowed, 6–8 x 2–3 mm;

stipules subulate, white, translucent, stiff, acuminate, undulate, semi-permanent, two on ventral and two on dorsal side of stem, 3–6 x 1 mm. *Flowers* solitary or seldom 2 together, axillary. *Pedicel* 2—3 mm long, succulent. *Sepals* 5, articulate, ovate or elliptic, some cucullate, membranous margined, acuminate, apex white, 4–5 x 1–1.5 mm. *Petals* 5, oblanceolate, apex acute or rounded, base with a long claw, weakly folded in the length, white or flushed with pink, 4.0–5.0 x 1.0–1.3 mm. *Nectar disc* fleshy, smooth, 10-lobed, lobes small, orientated downwards, the disc as a whole sloping gradually towards its periphery. *Stamens* 10; filaments nearly straight, terete, 3—4 mm long; anthers brown; staminal scales 10, simple, elliptic or obovate, apex truncate or acute, upper margins lacerate, 1.5 x 1.0–1.5 mm, ± 1/2 the length of the filament. *Ovary* conical, globulate; style terete; stigma simple. *Fruit* a septicidal, drooping schizocarp; succulent when fresh, yellowish-green, cylindric or ellipsoid, with 5, faint sutures visible, when dry brown, 5-lobed and wrinkled, 7–10 x 3–4 mm; partially breaking up in five mericarps remaining attached at apical end and partially encapsulated by the wrinkled exocarp, resembling a half open umbrella hanging upside down. Seed pyriform, 5—15 per locule, when immature attached by a long funicle. No mature seeds available for study (Figure 7.20.1).

Diagnostic characters and affinities

Z. giessii is distinguished by its overall greyish-white appearance (Figure 7.20.1.E) caused by the white, two-armed hairs present on all young parts as well as by the long, white, subulate stipules and long, filamentous rachis apices. It is also recognized by its simple, lacerated staminal scales and by its succulent, drooping, cylindric or ellipsoid fruits (Figure 7.20.1.D). It is allied to *Z. longicapsulare* which has a similar indumentum and similar floral and fruit morphology. Although very dense, the indumentum of *Z. longicapsulare* occurs mostly on the younger stems only and does not cause an overall greyish-white appearance as is seen in *Z. giessii*. These two species are distinguished by their different leaflets and stipules. The leaflets of *Z. giessii* are obovate with an acute apex and when young, are white, membrane-margined (Figure 7.20.1.B). The leaflets of *Z. longicapsulare* are orbiculate or obovate with an obtuse or rounded apex. The stipules of *Z. giessii* are subulate, white, with undulate apices and are 3–6 x 1 mm in size, whereas the

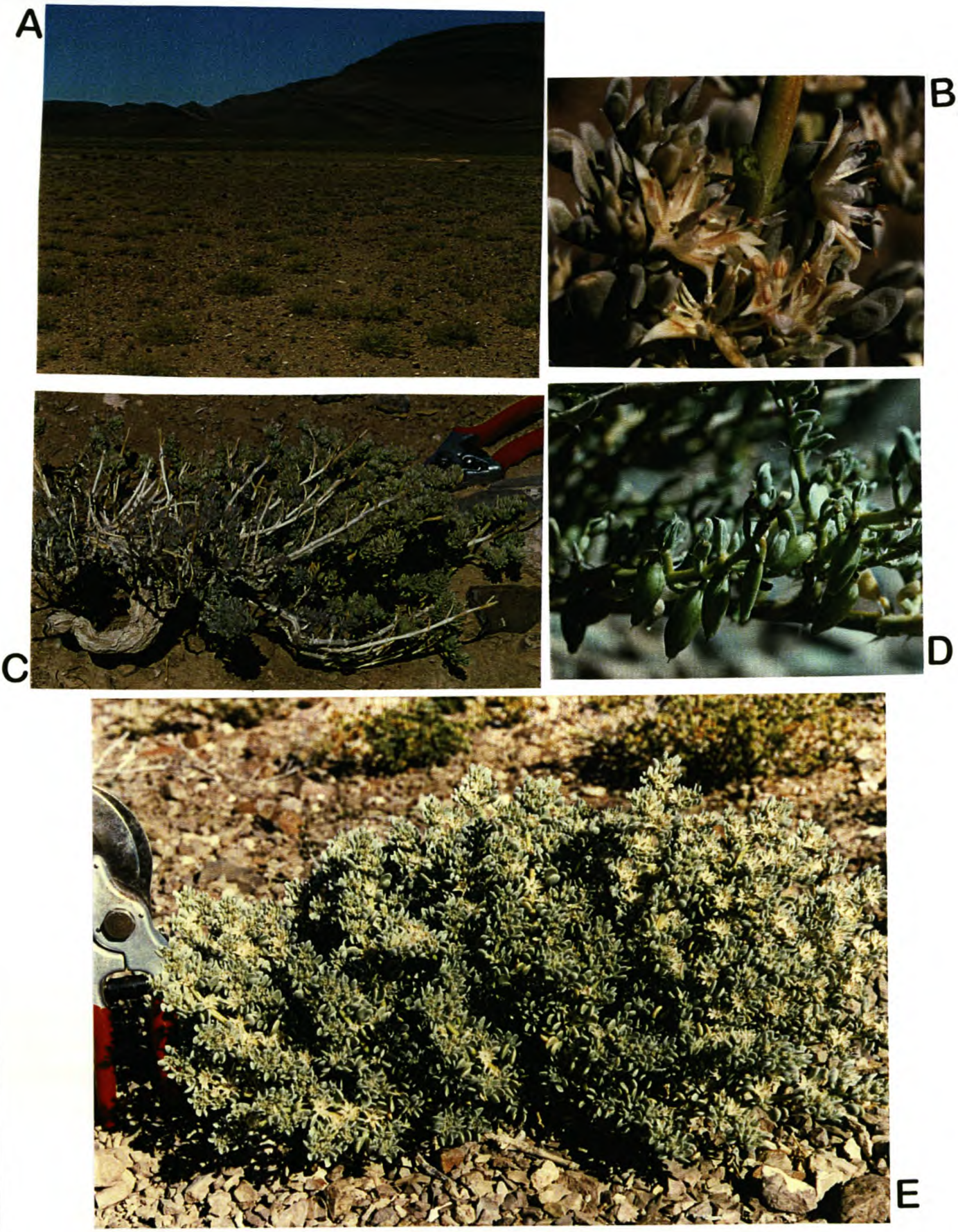


Figure 7.20.1. *Z. giessii, Van Zyl 4353.* A, habit on Arimas, Namibia; B, flowers with brown anthers and young leaves with margins white-membraned; C, plant with thick-stemmed, perennial basal part and thinner, "seasonal" branches showing grazing damage; D, twig with immature, elliptical, succulent fruits; E, plant displaying overall, greyish-white appearance.

stipules of *Z. longicapsulare* are triangular, brownish and 1 x 1.5 mm in size. The specific epithet commemorates J.W.H. Giess. Table 7.5 summarizes the characters of the species in § *Cinerea.*

Distribution and ecology

Z. giessii is found in the southern part of Namibia. Two adjoining farms, Arimas and Kolke, north-east of Rosh Pinah in the Luderitz district, are the only known localities of this species (Figure 7.20.2). It occurs in vegetation classified as **Nama Karoo Biome** with a low summer rainfall and high summer temperatures (Irish, 1994). Only two populations were found, a large one with *Z. giessii* the dominant species and another population consisting of scattered individuals along road sides. In both populations juveniles and seedlings occurred. The substrate is a mixture of dolemite and gravel on desert floors which are sparsely vegetated. *Z. giessii* occurs in association with other *Zygophyllum* species. Grazing damage does occur (Figure 7.20.1.C). Flowering period is from August to October. No properly mature fruits were seen.

The extremely limited range of this species, occurring in sheep farming area with resultant grazing damage, puts this species at risk for its future preservation.

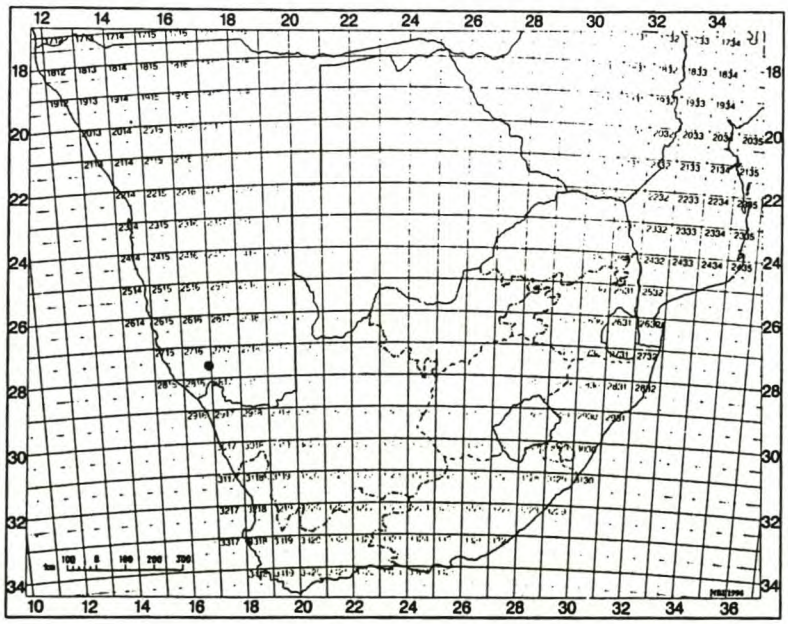


Figure 7.20.2. Geographical distribution of *Z. giessii.*

Specimens examined

–2716 (Witputz): On course sand - limestone flats on Arimas: LU 83 (–DB), *Giess 13828* (PRE, WIND); On bare loamy flats on Arimas: LU 83 (–DB), *Merxmüller & Giess 28888* (PRE, WIND); Flat valley floor of alluvium on Kolke (–DB), *Van Berkel 544/W23* (NBG, WIND); Limestone mixture at base of low dolomite ridge on Kolke (–DB), *Van Zyl 3907* (BOL, NBG, PRE, S); Limestone flats with gravel surface on Arimas (–DB), *Van Zyl 4351, 4353, 4407a* (NBG, PRE, WIND).

§ ***Grandifolia*** Engl. in Pflanzenwelt Afrikas.....3,1 : 735 (1915); Engl. 165 (1931); Huysst.: 67 (1937).

Type species: *Z. stapffii* Schinz.

Diagnostic features

Young stems with a flat ventral area
Leaves opposite, petiolate, bifoliolate, leaflets subrotund
Flowers 1—9 together, axillary
Nectar disc smooth, regularly 10-angled,
with 10, small lobes orientated out- and downward
and with nectaries visible as small groups of darker cells
Staminal scales simple, margins lacerate
Mature fruit oblong, 5-winged,
separating along both ventral and dorsal sutures
Seeds compressed subpyriform, with a short and thick funicle

Z. stapffii Schinz was placed in a monotypic § *Grandifolia* by Engler (1915) and his arrangement was upheld by Van Huyssteen (1937), who placed § *Grandifolia* in subgenus *Zygophyllum*. However, I considered the position of § *Grandifolia* Engler in subgenus *Zygophyllum* as incorrect when it became clear that *Z. stapffii* shows a greater affinity with subgenus *Agrophyllum* (Table 7.6). The presence of druse crystals in the mesophyll of leaves of *Z. stapffii* (Kuun 1997) corroborates this. Druse crystals are present in the mesophyll of species in subgenus *Agrophyllum*, whereas it is absent in leaves of subgenus *Zygophyllum*. Therefore *Z. stapffii* is now removed and placed in subgenus *Agrophyllum*. Table 7.6 summarizes some of the characters of subgenera *Agrophyllum* and *Zygophyllum* as well as *Z. stapffii*.

Table 7.6. Characters of subgenera *Agrophyllum* and *Zygophyllum* and *Z. stapffii*.

SUBGENUS ZYGOPHYLLUM	**Zygophyllum stapffii**	**SUBGENUS AGROPHYLLUM**
druse crystals absent in mesophyll	**druse crystals present** in mesophyll	**druse crystals present** in mesophyll
fruit a loculicidal capsule	fruit separating along both ventral and dorsal sutures	fruit a septicidal capsule
seeds oblong, not compressed, white aril present	**seeds sub-pyriform**, compressed, **funicula** short and thick	**seeds pyriform, sub-pyriform**, compressed, **funicula** present
flowers large, petals yellow, usually marked at base with red or brown, with short claws	**flower size medium, petals white, unmarked, obovate, with a long claw**	flowers small, **usually white**, rarely light yellow or orange, never marked at base, **with long claws**
sepals not articulate, not succulent	sepals adnate at base, not articulate, leathery in texture	sepals articulate and usually succulent
nectar disc regularly angled never lobed	**nectar disc regularly angled, 10-lobed,** lobes small and directed out and downward, with nectaries visible as groups of darker cells	**nectar disc angled and lobed,** lobes arranged into pairs, variously orientated
nectar disc always papillate	**nectar disc smooth**	**nectar disc smooth**
nectar disc uniformly level, not sloping or with raised or sunken areas	**nectar disc sloping slightly towards its periphery**	**nectar disc sloping towards its periphery, with raised and sunken areas**
mucilage structured, with long spiral inclusions of a uniform width	**mucilage structured, with short spiral inclusions that unravel at apex**	**mucilage structured, with short spiral inclusions that unravel at apex**
young stems usually flat on ventral side, with lateral ridges, or round in cross section	young stems with a flat ventral area but without ridges	young stems usually grooved

7.21 Zygophyllum stapffii *Schinz* in Verhandlungen Botanischen Vereins der Prov.....Brandenburg: 29 : 57 (1888); Schlechter & Diels in Schultze: 705 (1907);

Engl.: 735 (1915); Engl.: 165 (1931); Dinter ex Range: 247 (1934); Huysst.: 67 (1937); A.Schreib.: 104 (1963); A.Schreib. in Merxm.: 18 (1966). SYNTYPES - Namibia: Kuisebthal, Damaraland, *Stapff s.n.*, not found; Luderitz, *Pechuel-Lösche s.n.*, not found. Swakopriver mouth, Swakopmund, *Van Zyl 3791* (NBG, neo., designated here, PRE, WIND).

Zygophyllum marlothii *Engl.*: 31–32 (1888); Engl.: 32, t 4, (1889); A.Schreib.: 104 (1963); A.Schreib. in Merxm.: 18 (1966). ICONOTYPE - Bot. Jahrbucher 10 : 32, t 4b (1889), designated here.

Since no one could confirm the precise date of publication for either Schinz (1888) or Engler (1888) and because Engler's publication was supplemented by an illustration dated 1889, I have chosen *Z. stapffii* Schinz (1888) as the oldest name for this taxon.

Erect, many-stemmed, woody shrub, 0.6 x 1 m, reaching a height of 1.0 m and a diameter of 2.0 m when hummock forming in sandy areas and on dunes, but usually smaller. *Stems:* old stems nude, coriaceous, bark blackish to light gray or brown, with fine cracks; young stems greenish-brown, sparsely leafy, with a flat ventral area, but without lateral ridges. *Leaves* opposite, petiolate, bifoliolate; rachis apex filamentous, caducous; petiole articulate, cylindrical, 3—10 mm long; leaflets articulate, dark green, leathery, rotund or subrotund, succulent, conduplicate, apex round, base round or sometimes attenuate, 20–45 x 20–40 mm; stipules succulent, leathery, dark brown, widely triangular or sub-rotund, patent, one on ventral and one on dorsal side of stem, sometimes with a notched apex or distorted by secondary stem growth, caducous, 4–7 x 5–10 mm. *Flowers* up to 9 together, axillary. *Pedicel* 10—15 mm long, elongating in fruit to 25 mm. *Sepals* 5, ovate, leathery, not articulate, some with membranous margins, reflexed in fruit, 5–6 x 4 mm. *Petals* 5, obovate, apex round or acute, crenulate, emarginate, base with a long, thick claw, white, 10–11 x 3–4 mm. *Nectar disc* fleshy, smooth, regularly 10-angled, with 10 small lobes orientated downwards situated on its sides, the disc sloping slightly towards its periphery, with scattered nectaries visible as small groups of darker cells. *Stamens* 10; filaments terete, 6.5—7.0 mm long; staminal scales 10, simple, widely elliptic, margins lacerate, 4.0–5.0 x 2.5–3.0 mm, ± 2/3 as long as filament. *Ovary*

obovoid, apex obtuse, 5-lobed and ridged; style terete; stigma simple. *Fruit a* drooping, oblong or obovoid, 5-winged septifragal fruit, 17–21 x 14–16 mm in size, with a slender central body and membranous wings of 5—6 mm wide. *Seed* compressed subpyriform, 1–3 per locule, 5 x 3 mm, light brown, when immature attached by a short, thick funicle, producing structured mucilage when wet with short, spiral inclusions that seem to unravel at the apex, mucilage sometimes developing inside mericarp causing the seeds to be firmly glued to endocarp walls; embryo slightly curved (Figure 7.21.1).

Diagnostic features and affinities

Z. stapffii is distinguished by its large, rotund to sub-rotund, leathery leaflets, 20–45 x 20–40 mm in size (Figure 7.21.1.A), by its large, dark brown stipules, 4–7 x 5–10 mm in size, by its oblong or obovoid, 5-winged fruits that separate along both ventral and dorsal sutures (Figures 7.21.1.A and 3.13.A—B), by its subpyriform, compressed seeds and by its unusual, short and thick funicle. *Z. stapffii* resembles *Z. cordifolium* with regard to leaf shape and fruit morphology. The latter has similar subrotund, but sessile and simple leaves and similar, widely winged fruits. However, they differ greatly with regard to floral morphology and belong to different subgenera. *Z. cordifolium* has large, yellow flowers with markings on the petals, a papillate, regularly 10-angled nectar disc and oblong, arillate seeds and has a typical loculicidal capsule. *Z. stapffii* has small, unmarked, white flowers (Figure 7.21.1.B), a smooth nectar disc with raised and sunken areas, subpyriform, compressed seeds with a short, thick funicle and atypical fruits that separate along both dorsal and ventral sutures. These different structures necessitate the transference of *Z. stapffii* to the subgenus *Agrophyllum*. The specific epithet commemorates F.M. Stapff, a German collector active in Namibia. Table 7.6 summarizes some of the characters of subgenera *Zygophyllum* and *Agrophyllum* and *Zygophyllum stapffii*.

Distribution and ecology

Z. stapffii occurs along the northern Namibian coastline from Sanitatas in the north to Solitaire in the south (Figure 7.21.2). It occurs in a vegetation classified as **Desert**

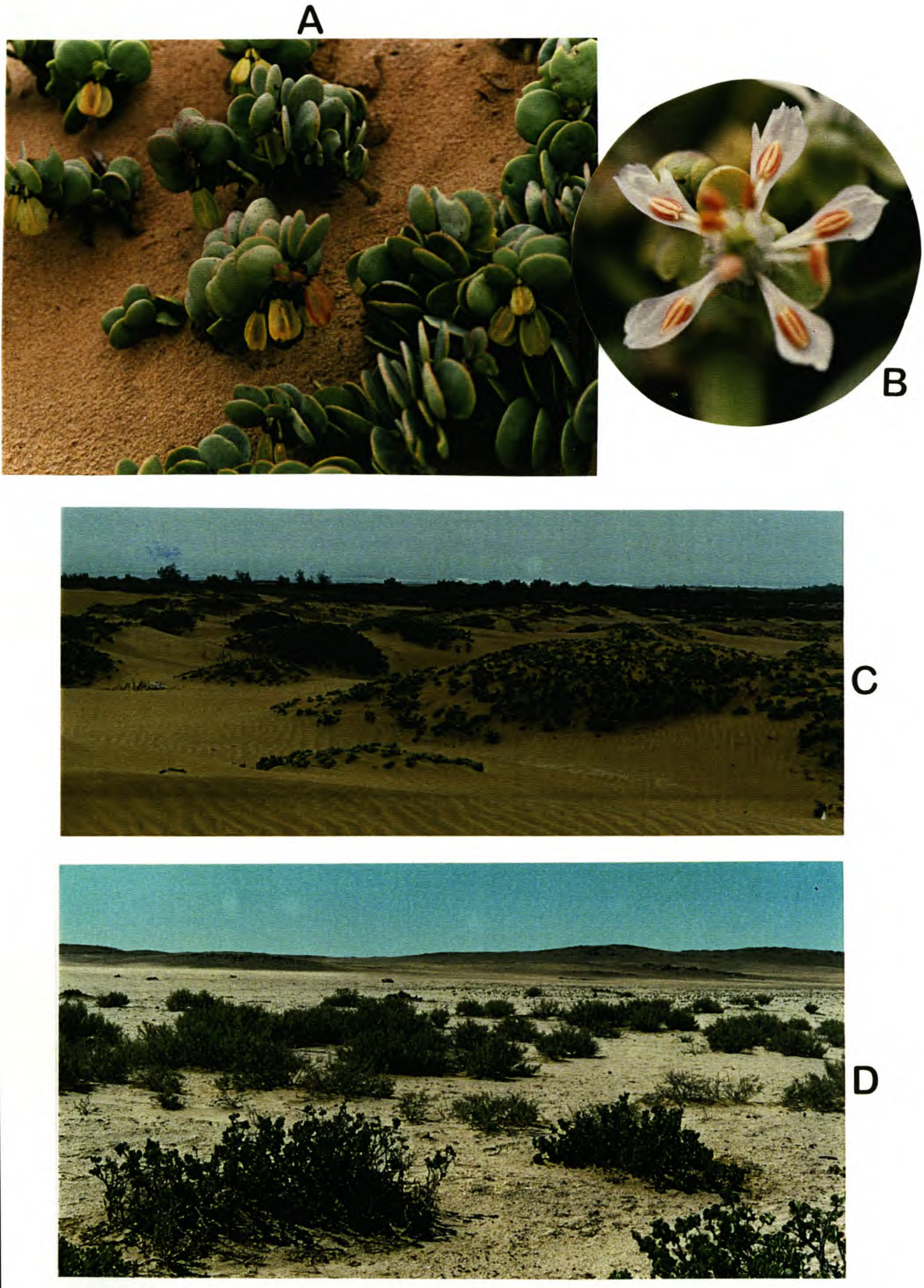


Figure 7.21.1. *Z. stapffii*, A—C, *Van Zyl 3791*; D, *Van Zyl 3793*. A, stem tips visible above hummock of sand displaying fruits and conduplicate, orbicular leaflets; B, flower with unmarked, white petals; C, hummock formation in estuary at Swakopmund; D, habit on Tumas flats in Namib Naukluft Park.

Biome (Irish 1994), with overall chaemaephytic - therophytic co-dominance. This Biome receives predominantly summer rainfall, but the chamaephytes, like *Z. stapffii*, supplement their water requirements by utilizing moisture from regular coastal fogs (Walter 1976). *Z. stapffii* occurs in dry water courses, in shallow depressions on bare, gravel flats or on rocky slopes. It also occurs in moist, salty sand next to beaches or in estuaries where it acts as a sand binder forming hummocks (Figure 7.21.1.C). Small populations of a few, scattered individuals, or larger populations, where this species dominates the plant communities, occur. Grazing damage is rare. Juveniles or seedlings are rare. Engler (1888) stated that this species, when green and alive, could be used as firewood. *Z. stapffii is* extremely resistant to drought and will survive in areas where even the resilient *Sarcocaulon* species perish.
Common name: dollar bush.

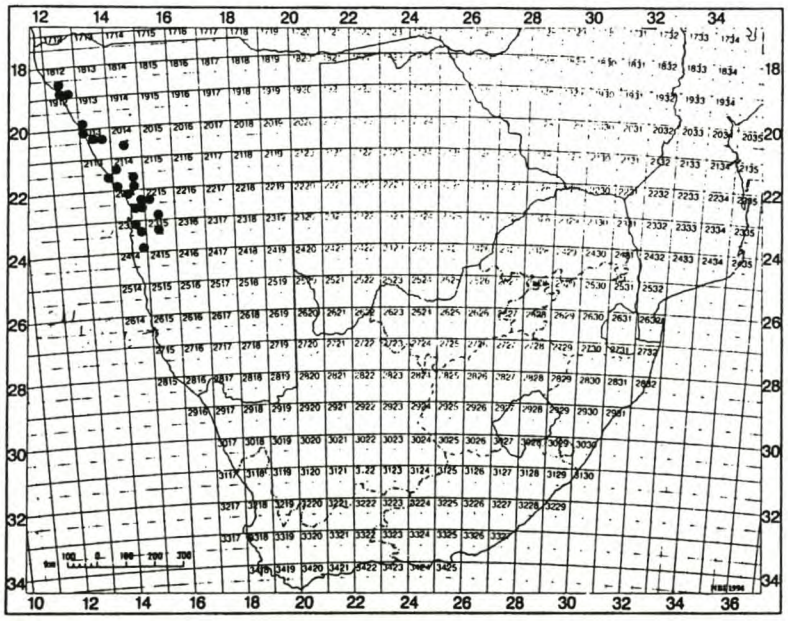


Figure 7.21.2. Geographical distribution of *Z. stapffii*.

Specimens examined

–1812 (Sanitatas): On gneiss at foot of Ogams hills (–CB), *Jacobsen & Moss K172* (WIND); 40 M from Rocky Point to Ompembe (–CD), *Kotze 122* (WIND); Near Rocky Point, Namib (–DC), *Hall 396* (NBG).

–1913 (Sesfontein): Terrace Bay (–CC), *Du Plessis s.n.* (NBG).

–2013 (Unjab Mouth): First vlei N of Torra Bay (–AA), *Giess 9065* (WIND); 16 km N of Torrabaai (–AA), *Giess 8002* (PRE, WIND); 137 km W of Welwitschia on road to Torrabaai (–AD), *De Winter & Hardy 8171* (PRE, WIND); 34 km W of Wêreldsend on road to Torrabaai (–BC), *Giess 7983* (WIND).

–2014 (Welwitchia): Rocky slopes on Twyfelfontein, Damaraland (–CB), *Craven 146* (WIND).

–2113 (Cape Cross): In the area where Welwitchia grows along coast near Cape Cross (–DB), *Rodin 8903* (WIND).

–2114 (Uis): In rocky donga on Cave Mountains (–AC), *Giess 9707* (WIND); Between rocks on Messumberge (–AC), *Giess 9164* (WIND); On slopes and in dongas on Lagunenberg at Cape Cross (–CC), *Giess 3558* (PRE, WIND); Sandy plains 63 km NE of Hentiesbaai on road to Uis (–DA), *Goldblatt 1977* (NBG, PRE, WIND); 55 km NE of Hentiesbaai (–DA), *Greuter 20306* (WIND); 34 km E of Hentiesbaai on road to Usakos (–DC), *Van Zyl 3789* (NBG); 35 km E of Salzpad from Marmor-Quarzhang, Omaruru (–DC), *Giess 7856* (WIND.

–2214 (Swakopmund): In the Namib, 5 km E of Hentiesbaai (–AB), *Merxmüeller & Giess 1728* (PRE, WIND); Namib desert, 30 M E of Swakopmund (–BD), *Barker 10711* (NBG); N of Arandis (–BD), *Craven 1628* (WIND); Lower Ostrich River, Rossing Mine area (–BD), *Craven 1555* (WIND); Upper Ostrich River, Rossing Mine area (–BD), *Craven 1541* (WIND); Namib near Swakopmund (–DA), *Cannon s.n. Marloth 10195* (PRE); In Swakopmund Strandveld, on road to Hentiesbaai (–DA), *Bean, Vlok & Viviers 1863* (BOL); Swakoprivier mouth (–DA), *Galpin & Pearson 7488* (PRE, SAM), *Seydel 1656* (LISC), *De Winter 3196* (WIND), *Von Teichman 464* (PRE), *Van Zyl 3791* (NBG, PRE, WIND), *Pearson 534* (SAM), *Rauh 49359* (WIND); On rocks at Swakopmund (–DA), *Bradfield 465* (PRE); Rosenquartz Kuppe at Rossing (–DB), *Watt 65* (WIND); Namib desert near Goanikontes (–DB), *Rodin 2160* (BOL, PRE); Coastal Namib flats, 22 M NE of Swakopmund on Usakos road (–DB), *Hardy 2065* (WIND).

–2215 (Trekkopje): In depressions on Stokpile site at Rossing Mine (–AC), *Craven 1608* (WIND), *Craven 1576* (WIND); N of Arandis on N2 (–AC), *Van Zyl 3786* (NBG, PRE); Bloedkoppie W of Tinkas in Namib Desert Park (–CD), *Oliver, Muller & Steenkamp 6591* (PRE).

–2314 (Sandwich Harbour): Kuisep flushbed, Rooibank, Walvisbaai (–BA), *Schenk 412* (Z); E slopes of Swartbankberg near Kuiseb (–BD), *Giess 2275* (PRE, WIND); W aspect of Swartbankberg, Namib Naukloof Park (–DD), *Van Wyk 4425* (PRE).

–2315 (Rostock): 80 km N of Solitaire on road to Walvis Bay in Namib Naukloof Park (–AD), *Van Zyl 3792* (NBG); Tumas flats, SE of Walvis Bay in Namib Naukloof Park (–AD), *Van Zyl 3793* (NBG, WIND).

Unknown or no precise locality: On road between Uis and Henties Bay, S of Brandberg, *Tinley 1589* (WIND); Approximately 40 M from Swakopmund near Welwitchiaflache, *Brink 569* (GRA).

Subgenus *Zygophyllum*

Subgenus *Zygophyllotypus* Huysst.: *Morphologisch-systematische Studien…..:* 64 (1937); El Hadidi, 49 (1978).

Genus *Fabago* Adan., Familles de Plantes 2 : 507 (1763).

Section? *Fabago* Endl., Genera Plantarum 1161 (1841).

Young stems round in cross section with a flat ventral area and prominent lateral ridges, or with several less prominent ridges or striate all around, sometimes rhombic or elliptic and without any ridges (Figure 3.1); indumentum when present consisting of unicellular hairs which can be straight or curly or woolly, short or long, dense or sparse; stipules fused or partially fused, rarely free; flowers single or two or more together, axillary; petals usually yellow, rarely white or cream coloured, rarely white and red-veined, usually marked at base, rarely unmarked, base with a short claw, rarely zygomorphic; staminal scales simple, usually obovate, apex obtuse, truncate or v-shaped, margins lacerate, sometimes bordered with papillae; nectar disc always papillate, regularly 10-angled, never lobed, (Type 1; Table 3.4); ovary (4-) 5-locular, glabrous; fruits usually loculicidal capsules or septifragal (*Z. morgsana*), categorized as 5-lobed without ridges, 5-lobed with ridges or 5-winged, rarely succulent (Figures 3.8—10); seeds oblong, arillate, usually few per locule, producing structured mucilage when wet with long, spiral inclusions of a uniform width.

§ *Paradoxa* Huysst., *Morphologisch-systematische Studien über die Gattung* Zygophyllum……: 67 (1937).

Type species: *Z. cordifolium* L.f

Diagnostic features

Young stems round in cross section

Leaves opposite, simple, sessile or contracted into a petiole that is not articulate, widely obovate, spathulate, subrotund

Flowers 1–3 together, axillary

Nectar disc papillate, regularly 10-lobed

Staminal scales simple, apex truncate, rounded or v-shaped, with lacerated margins

Mature fruit a loculicidal capsule, 5-angled or 5-winged

Three species, *Z. cordifolium* , *Z. orbiculatum* and *Z. paradoxum* were included in the original publication of § *Paradoxa* by Van Huyssteen (1937). Schreiber (1963) placed *Z. paradoxum* into synonymy with *Z. cordifolium,* which I accept. *Z. fusiforme* is now added, bringing the total number of species in this section up to three again. Table 7.7 summarizes the characters of the species in § *Paradoxa.*

Key to species in § *Paradoxa*:

1a Mature fruits oblong or obovate, not suculent, 5-winged.....2

1b Mature fruits fusiform, succulent when fresh, ellipsoid and 5-angular when dry.....*Z. fusiforme*

2a Leaf base attenuate, contracted into a 5–10 mm long petiole, fruits obovate, 5-winged, with slender central bodies and 5 mm wide wings.....*Z. orbiculare*

2b Leaf base obtuse, cordate or somewhat cuneate, but without a petiole, fruits oblong, 5-winged, with strong, thick central bodies and 2—5 mm wide wings.....*Z. cordifolium*

Tabel 7.7. Characters of the species in § *Paradoxa*

Z. CORDIFOLIUM	Z. FUSIFORME	Z. ORBICULATUM
erect or decumbent shrub or shrublet, (0.1-)0.4(–1.0) x (0,2-)0.6(–0.8) m	decumbent soft shrublet 0.3 x 0.4 m	erect shrub, 0.5 x 0.5 m
leaves simple, sessile 20–50 x 16–60 mm	leaves simple, sessile 13–27 x 12–25 mm	leaves simple, petiolate 20–50 x 16–60

—	—	petiole 5—10 mm long petiole not articulate
nectar disc fleshy, papillate, 10-angled	nectar disc fleshy, papillate, 10-angled	?
staminal scales simple, apex truncate or v-shaped, margins lacerate	staminal scales simple, apex truncate or rounded, margins lacerate	?
ovary ovoid, elliptic or oblong, 5-lobed, winged	ovary narrowly fusiform, sutures visible	?
fruit oblong, 5-winged, central body thick, strong, wings 2–5 mm wide	fruit fusiform, succulent when fresh, ellipsoid, 5-angled when dry	fruit obovoid, 5-winged, central body thin, wings 5 mm wide

7.22 Zygophyllum cordifolium *L.f.,* Supplementum plantarum: 232 (1782); Ait.: 60 (1789); Thunb.: 80 (1794); Willd.: 560 (1799); Pers.: 463 (1806); Thunb.: 543 (1823); DC.: 705 (1824); Eckl. & Zeyh.: 95 (1835); Sond.: 356 (1860); Schlechter & Diels in Schultze: 704 (1907); Huysst.: 67 (1937); A.Schreib.: 76 (1963); A.Schreib. in Merxm.: 15 (1966); Bond & Goldblatt: 437 (1984). TYPE - Without locality, *Thunberg sheet number 10123* (UPS-THUNB, holo!).

Zygophyllum paradoxum *Schinz*: 155 –156 (1888); Huysst.: 67 (1937); A.Schreib.: 76 (1963); A.Schreib. in Merxm.: 15 (1966); ex descr. Schinz mentioned 3 syntypes: Angra Pequena, *Schenck 88*; Between Aus and Orange River, *Schenck 224*; Klein Fonteyn, Namibia, *Pohle s.n.*, none of which was traced in any of the following herbaria: B, C, GB, H, KIEL, L, M, MB, S, UPS, W, Z.

Zygophyllum pfeilii *Engl.:* 244 (1897); Huysst.: 67 (1937); A.Schreib.: 76 (1963); A.Schreib. in Merxm.: 15 (1966); ex descr. TYPE - Namibia: Port Nolloth - Oakuep, *J Graf Pfeil 51* (B†).

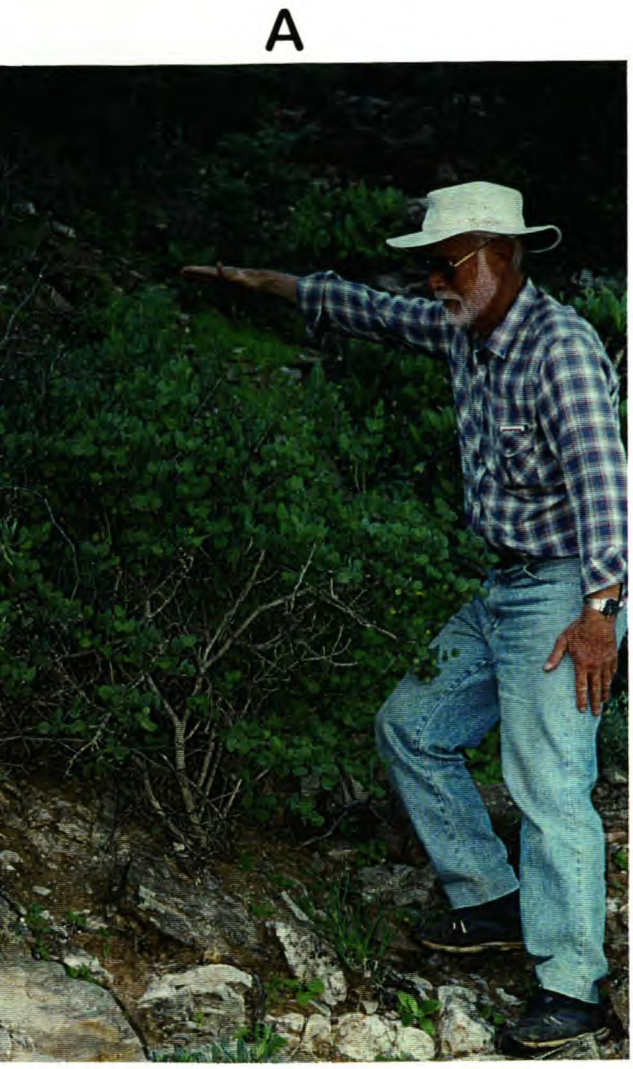
The Curator of B, Dr. Leuenberger, confirmed the loss of this specimen during the 2nd World War. No other was traced in any of the following Herbaria: B, C, GB, H, KIEL, L, M, MB, S, UPS, W, Z.

Zygophyllum schaeferi *Engl.*: 732 (1915), Fig 341 A—E, fig. solum; Engl.: 163 (1931) Fig. 75, A–E, fig. solum.

Erect or decumbent, many-stemmed shrub or shrublet, reaching a height of (0.1-) 0.4 (–1.0) m and a diameter of (0,2-)0.6 (-0.8) m. *Stems*: old stems nude, bark rough, gray; younger branches smooth, pale-green or brownish, round in cross section, without ridges or flat areas. *Leaves* opposite, sessile, simple, articulate, glaucous, fleshy, subrotund or widely obovate, 20–50 x 16–60 mm, apex round, base cordate, obtuse or cuneate; stipules navicular, membranous, margins ciliate, reflexed, caducous, one each on ventral and dorsal side of stems, sometimes with apex notched, 2–3 x 1–2 mm. *Flowers* solitary or two together, axillary. *Pedicel* 10—28 mm long. *Sepals* 5, ovate or elliptic, some with membranous margins, 6–10 x 3–6 mm. *Petals* 5, pale yellow, lime yellow or golden yellow, variously marked at base with red, brown or khaki, U-shaped figures or streaky blotches, rarely unmarked, obovate or ovate, apex obtuse, often emarginate, base with a short claw, 12–18 x 5–9 mm in size. *Nectar disc* fleshy, papillate, 10-angled. *Stamens* 10; filaments terete, 6—10 mm long; staminal scales 10, simple, oblong or narrowly obovate, apex truncate or v-shaped, upper margins of scale lacerate, 3.0–6.0 x 1.5–3.0 mm, ± ½ the length of the filament. *Ovary* ovoid, ellipsoid or oblong, 5-lobed with rudimentary wings; style terete, stigma simple. *Fruit* a drooping, glaucous or green, hidden between leaves, oblong, 5-winged, loculicidal capsule, 10–34 x 9–18 mm, apex usually retuse, wings reticulate-veined, 2—5 mm wide. *Seed* oblong, 1–4 per locule, 5.0 x 2.5 mm, dark brown with white aril, testa glossy, smooth, producing brownish, structured mucilage with long, spiral inclusions of uniform width when wet (Figure 7.22.1).

Diagnostic characters and affinities

Z. cordifolium is distinguished by its simple, sessile, cordate (hence the specific epithet), subrotund or widely obovate leaves, by its staminal scales that are V-



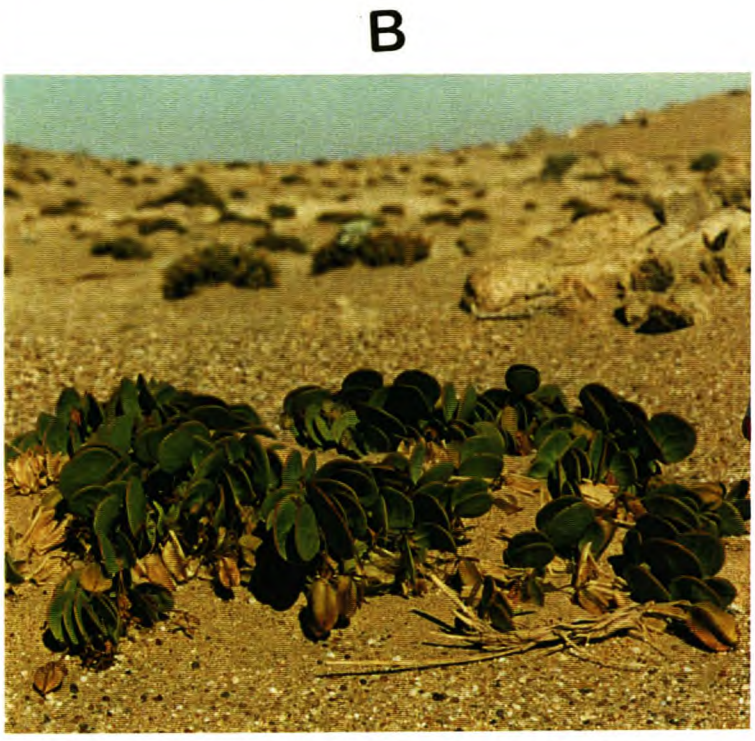


Figure 7.22.1. Variation in habit and habitat of *Z. cordifolium*. A, erect, 1 m tall shrub on Anniskop, Richtersveld, *Van Zyl 4496*; B, dwarf habit in the Namib, near Luderitz, *Van Zyl 3875*; C, decumbent, lush, succulent habit near Doringbaai, *Van Zyl 4010*.

shaped or truncate and lacerate on upper margins and by its prominently 5-winged fruits. It is allied to the species in § *Paradoxa*, all of which have simple leaves. With regard to leaf and flower structures, *Z. cordifolium* is close to *Z. fusiforme*, but the latter has wingless fruits. With regard to fruiting structures, it is close to *Z. orbiculatum,* but the leaf bases of the latter are attenuate in a narrow petiole of 5—10 mm long. *Z. cordifolium* resembles *Z. prismatocarpum*, *Z. patenticaule* and *Z. pterocaule* with regard to their simple leaves, but the latter three species belong to § *Prismatica*, subgenus *Agrophyllum* and have very different, small, unmarked, white flowers and septicidal schizocarps. *Z. cordifolium* can be confused with *Z. stapffii* because of their similar leaf shapes, but those of the latter are bifoliolate and petiolate and based on flower morphology, *Z. stapffii* belongs to the monotypic § *Grandifolia* of subgenus *Agrophyllum*. Table 7.7 summarizes the characters of the species in § *Paradoxa*.

Distribution and ecology

Z. cordifolium occurs in a wide strip along the low lying parts of the west coast of South Africa and Namibia (Figure 7.22.2). The northern boundary of its distribution is at Luderitz in Namibia and in the south it reaches the Langebaan peninsula. A few outlyer collections were made on the eastern side of the Cedar Mountains in the Tanqwa Karoo. In Namibia it occurs in vegetation classified as **Desert Biome** and **Succulent Karoo Biome** (Irish 1994). Both Biomes have a low, predominantly winter rainfall with extremely hot and dry summers. In South Africa *Z. cordifolium* is found in a vegetation classified as **Thicket Biome**: Dune Thicket (Lubke 1996) and **Succulent Karoo Biome**: Strandveld Succulent Karoo, Upland Succulent Karoo and Lowland Succulent Karoo (Hoffman 1996). Rainfall also occurs during winter months, with the Dune Thicket receiving 900—1500 mm per annum and Succulent Karoo Biome 50—300 mm per annum. Flowering starts in autumn and continues through the winter, ending in October. In the Strandveld Succulent Karoo, which occurs in a narrow strip along the west coast, populations of *Z. cordifolium* are abundant, lush, soft and reclining, succulent and often dominant within communities (Figure 7.22.1.C). Populations of *Z. cordifolium* further inland, in

the adjacent Lowland Succulent Biome, are less succulent, with smaller leaves and erect, woody stems, and are not dominant within the vegetation. Towards its drier, northern boundary, *Z. cordifolium* is sometimes a large, thick-stemmed shrub of 1.0 m high if situated in a protected spot (Figure 7.22.1.A), or it can be a dwarf shrublet, hardly reaching 0.1 m in height when exposed to harsh desert conditions as at Luderitz (Figure 7.22.1.B). Although the habit and vegetative morphology of this species vary considerably, the basic flower and fruit morphology remains constant and the subdivision of the species was not considered necessary. *Z. cordifolium* is drought deciduous and becomes completely leafless in response to water stress. A quick resprouting ability is seen soon after rains. Grazing damage is rare and it can be assumed that this species is not palatable. Because of its large distribution and the many and large populations, this species is not considered threatened at present. Common name: geldjiebos.

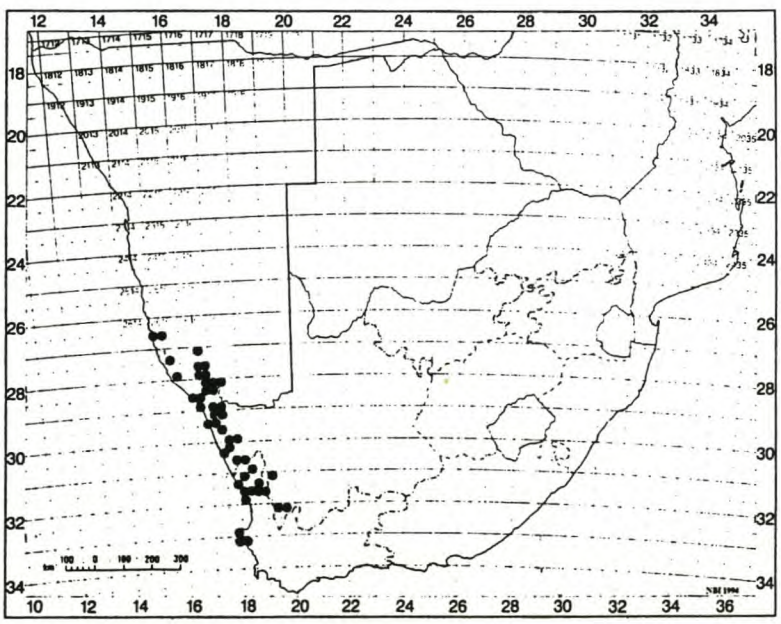


Figure 7.22.2. Geographical distribution of *Z. cordifolium*.

Specimens examined

–2615 (Luderitz): Kohlmanskop, E of Luderitz (–CA), *Van Zyl 3875* (NBG, PRE, WIND); Luderitzbucht (–CA), *Range 490* (SAM); Dias Point, Luderitz (–CA), *Müller & Jankowitz 297* (PRE, WIND); Between turn off to Griffiths Bay and Grossebucht (–CA), *Van Zyl 3876* (NBG);

Slopes of Nautilus, Luderitz (–CA), *Kinges 2027* (PRE); N of Nautilus, Luderitz (–CA), *Merxmüller & Giess 3077* (PRE, WIND); *Range 17* (SAM); Swartberge, 6 M from Luderitz on road to Diazpunt (–CA), *Giess & Van Vuuren 718* (WIND); Limestones at Haalenberg (–CB), *Dinter 6661* (BOL, NBG, Z); *Dinter 4098* (SAM); *Van Zyl 3866* (NBG).

–2715 (Bogenfels): Sandy plain E side of Klinghardtsberge (–BC), *Müller 820* (WIND); Summit of Buchuberg (–DD), *Williamson 2579* (BOL); S aspect of Buchuberg (–DD), *Merxmüller & Giess 28358* (WIND).

–2716 (Witputz): Limestones between Kuchaus and Pockenbank (–BA), *Dinter 3717* (BOL, PRE, SAM, Z); Gneiss hills at Kawarass (–BA), *Marloth 12425* (NBG); Hills between Rosh Pinah and Obib F, Diamond Area No. 1 (–CB), *Owen-Smith 1309* (WIND); Limestone flats on Sud Witputz 31, N of Rosh Pinah (–DA), *Van Zyl 3903* (NBG, PRE); Arimas/Kolke, N of Rosh Pinah (–DB), *Van Zyl 4420* (NBG); Next to track in Sperrgebiet (–DC), *Van Berkel 540/W6* (NBG); Rocky mountainside 6 km W of Rosh Pinah at gate to Diamond Area No. 1 (–DC), *Van Wyk 8919* (PRE); Spitzkop (–DC), *Leipert 4189* (WIND); Sperrgebiet, Spitzkop (–DC), *Van Berkel W6* (WIND); Zebrafontein: LU 87, N of Rosh Pinah (–DC), *Van Zyl 4348* (NBG); Spitzkop 111, 10 km N of Rosh Pinah (–DC), *Van Zyl 3900* (NBG, PRE, WIND); Namuskluft 88 (–DD), *Mittendorf 125* (WIND); *Logan 390* (WIND); Zebrafontein: LU 87 (–DD), *Giess 12877* (PRE, WIND); Stony flats on Witputz Sud (–DB), *Oliver & Müller 6405* (PRE).

–2816 (Oranjemund): Rosh Pinah pump station (–BB), *Van Zyl 3911* (NBG, PRE); State ground at Lorelei Mine (–BB), *Van Zyl 4344* (NBG); Steep S aspect of Anniskop, Richtersveld (–BD), *Van Zyl 4072* (NBG); *Van Zyl 4140* (BOL, NBG, PRE, WIND); Pokkiespramberg (–BD), *Metelerkamp 75* (BOL); Grasvlakte, at turn off to Helskloof (–BD), *Van Zyl 3918* (NBG, WIND); Valley in Helskloof (–BD), *Van Zyl 4504* (BOL, NBG, WIND); Top of Numiesberg, Khubus (–BD), *Raitt 327* (NBG); Sandy coast at Alexander Bay (–CB), *Roux 27* (BOL); Gate No. 1 on Alexander Bay to Port Nolloth road (–DA), *Rösh & Le Roux 558* (PRE); 45 M N of Port Nolloth on road to Alexander Bay (–DA), *Werger 493* (PRE); 2 M E of Oppenheimer Bridge (–DA), *Leistner 3430* (WIND); 10 km S of Alexander Bay (–DA), *Van Zyl 4076* (NBG. WIND); Swartbank area, S of Alexander Bay (–DC), *Van Zyl 4077* (NBG).

–2817 (Vioolsdrif): Between confluence of Boom and Dabimub Rivers with the Orange (–AA), *Van Zyl 4477* (NBG, WIND); Opposite Oena Mine on N side of Orange River (–AA), *Van Zyl 4341* (BOL, NBG, WIND); Main ridge S of Beacon and up to summit on Kodaspiek (–AA), *Oliver, Tölken & Venter 455* (K, NBG, PRE); NW of Grootpenseiland on way to Rooilepel (–AB), *Van Zyl 4329* (NBG); Gneiss hills at Kawarass (–AC), *Marloth 12425* (NBG, PRE); Near Rooihoog, S of Eksteensfontein (–CC), *Van Zyl 4048* (NBG); Kourkamma Mountains (–CD), *Van Zyl 4088* (NBG); Near Kliphoogte, 20 km SE of Eksteensfontein (–CD), *Van Zyl 4042* (NBG); Quarts hill at Eksteensfontein (–CD), *Van Zyl 4496* (NBG).

–2916 (Port Nolloth): Near Port Nolloth (–BD), *Bolus 9401, 6684* (BOL); McDougall's Bay (–BD), *Scheffler 269* (NBG); *Raitt 307* (NBG, PRE).

–2917 (Springbok): Karuchabpoort 9 km S of Lekkersing (–AA), *Oliver, Tölken & Venter 771* (NBG, PRE); Between Boesmanpunt and Sabieboomrante (–AB), *Van Zyl 4038* (NBG); 10 km

on Wolfberg turn off from Port Nolloth - Steinkopf road (–AC), *Van Zyl 4082* (NBG); Noupoortsberg, W of Springbok (–CB), *Van Zyl 4086* (NBG); Wildeperdehoek, NW of Kamieskroon (–DC), *Van Zyl 4091* (NBG); Dry stream bed, 35 km S of Springbok (–DD), *Goldblatt 2251* (NBG, PRE).

–3017 (Hondeklipbaai): Hills SE of Hondeklipbaai (–AD), *Pillans 17953* (BOL); 4 km S of Soebatsfontein (–BA), *Van Zyl 4093* (NBG); *Lewis 1701* (SAM); Top of Sabieskop (–DB), *Van Berkel 391* (NBG).

–3018 (Kamiesberg): 10 km S of Garies (–CA), *Hugo 2893* (NBG, PRE); Loerkop, S entrance to Studor's Pass (–CA), *Van Zyl 4106* (NBG, PRE); Doornkraal road, SE of Garies (–CA), *Van Zyl 4129* (BOL, NBG, PRE); Near Kwanous, N of Bitterfontein (–CD), *Van Zyl 3750* (NBG).

–3117 (Lepelfontein): Red sands at Brand se Baai (–BD), *Van Zyl 4010* (NBG); *Van Breda 4525* (PRE).

–3118 (Vanrhynsdorp): 6 km N of Komkans on road to Kotzesrus (–AA), *Van Zyl 4368* (NBG); Mierhoofd Kasteel (–AA), *Barker 6203* (NBG); *Lewis 2938* (SAM); Hendriksvlei, N of Nuwerus (–AA), *Van Zyl 4008* (NBG); 30 km N of Vanrhynsdorp along N7 (–BC), *Van Zyl 4128* (NBG); Rooiberg, 25 km N of Holrivier (–BC), *Van Zyl 4013* (NBG); Geelwal, Karoo-on-sea, Vredendal area (–CA), *Le Roux & Ramsey 95* (PRE); Near Holrivier Stasie (–CB), *Van Zyl 3656* (NBG); 0.7 km from the main road to Lossand Railway Station, Vredendal (–CB), *Le Roux 2143* (NBG); Liebendal, between Vredendal and Lutzville (–CB), *Van Zyl 3597* (BOL, NBG, PRE); Vlermuisklip (–CB), *Herre s.n.* (STE12087 in NBG); Sea dunes at Strandfontein (–CC), *Van Zyl 3602* (BOL, NBG, PRE); *Hall 4245* (NBG, PRE); *Thompson 32* (NBG); Vanrhynsdorp (–DA), *Compton 7267* (NBG); 10 M N of Vanrhynsdorp along N7 (–DA), *Marsh et al. 321* (NBG); Urionskraal, E of Vanrhynsdorp (–DB), *Van Zyl 3958* (BOL, NBG, PRE); Troe-Troe, 3 km from Vanrhynsdorp on road to Nieuwoudtville (–DB), *Le Roux 2005* (NBG); Raskraal, SE of Vanrhynsdorp on road to Mauwerskop (–DB), *Oliver 4961* (PRE); Zandkraal, 16 km from Vanrhynsdorp (–DB), *Van Breda 4224* (NBG, PRE).

–3119 (Calvinia): Near Kokerboomkop, Calvinia (–AB), *Lewis 4126* (SAM).

–3217 (Vredenburg): Betwen Hopefield and Paternoster (–DD), *Leipoldt 4039* (PRE); 1 M E of Paternoster (–DD), *Barker 9691* (NBG); Tietiesbaai (–DD), *Van Zyl 4195* (NBG); *Taylor 578* (NBG).

–3219 (Wuppertal): Gerustheid, next to Doringrivier, Calvinia (–AB), *Van Zyl 4214* (NBG, PRE); N of Reenen, Ceres Karoo (–BA), *Van Zyl 4209* (NBG).

–3317 (Saldanha): Saldanha (–BB), *Ecklon & Zeyher 752* (SAM); *Parker 4635* (NBG); *Leipoldt 4039* (BOL); Danger Bay, Saldanha (–BB), *Hall 717* (NBG); *Leighton 1732* (BOL); Hoedtjiesbaai (–BB), *Mac Vae 1103* (SAM); *Hall 708* (NBG); Peninsula W of Langebaan (–BB), *Pillans 6961* (BOL); W slopes of Postberg, Langebaan (–BB), *Barker 10466* (NBG).

–3318 (Cape Town): South Head, Langebaan Peninsula (–AA), *Boucher 2811* (NBG).

Unknown or no precise localities: Calvinia, *Schmidt 307* (PRE); Road from Buffelsrivier to Soebatsfontein, *Leighton 1208* (BOL); Dornrivier, *Schlechter 8066* (BOL, PRE); Between

Loeriesfontein and Nieuwoudtville, *Maguire 202* (NBG); At Olifantsrivier on karoo hills, *Drège s.n.* (TCD s.n.). *Thunberg sheet number 10123* (UPS-THUNB).

7.23 Zygophyllum fusiforme *Van Zyl*, sp. nov., (§ *Paradoxa*), *Z. cordifolio* foliis succulentibus subrotundis floribusque similibus affinis, sed fructu fusiformi succulento, sectione rotundo, suturis inconspicuis in fructu vivo, 5-angulato in fructu secco, numquam late alato, ut in *Z. cordifolio*. TYPE - Northern Cape: Near Skouerfontein, NW of Eksteensfontein, Richtersveld, *Van Zyl 4495* (NBG!, holo, B!, BOL!, PRE!, S!, WIND!).

Decumbent shrublet with many stems neatly radiating from the center, reaching a height of 0.3 m and a diameter of 0.4 m. *Stems*: old stems brittle, nude, smooth, gray; younger stems smooth, reddish-brown, round in cross section, not ridged. *Leaves* opposite, sessile, simple, articulate, green or glaucous, fleshy, subrotund or widely obovate, apex rounded, base obtuse or cuneate, never cordate, 13–27 x 12–25 mm; stipules navicular, membranous, margins ciliate, reflexed, caducous, one on ventral side and one on dorsal side of the stem, rarely with shallowly notched apex, 1 x 1 mm. *Flowers* solitary or two together, axillary. *Pedicel* 7—15 mm long. *Sepals* 5, ovate, obovate or elliptic, apex acute, some with membranous margins, 5–6 x 2–4 mm. *Petals* 5, obovate or elliptic, 13–16 x 4.5–6 mm, apex obtuse, often emarginate, base with a short claw, pale yelow or lime yellow, variously marked at base with reddish-brown or khaki, vaguely M-shaped figures, or without marks. *Nectar disc* fleshy, papillate, 10-angled. *Stamens* 10; filaments terete, 7.5—9.0 mm long; staminal scales 10, simple, oblong or obovate, apex truncate or rounded, margins of upper half of scale lacerate, 2–3 x 1.3–1.5 mm, ± 1/3 the length of the filament. *Ovary* fusiform, with sutures faintly visible; style terete; stigma simple. *Fruit* a drooping, loculicidal capsule, hidden amongst leaves; when fresh glaucous or green, soft, succulent, fusiform, sutures faintly visible; when dry ellipsoid, 5-angled, exocarp wrinkled, 15–21 x 5–9 mm. *Seed* oblong, 1—4 per locule, 4 x 2 mm, dark brown with white aril, testa smooth and glossy, producing brownish, structured mucilage with long, spiral inclusions of uniform width when wet (Figure 7.23.1).

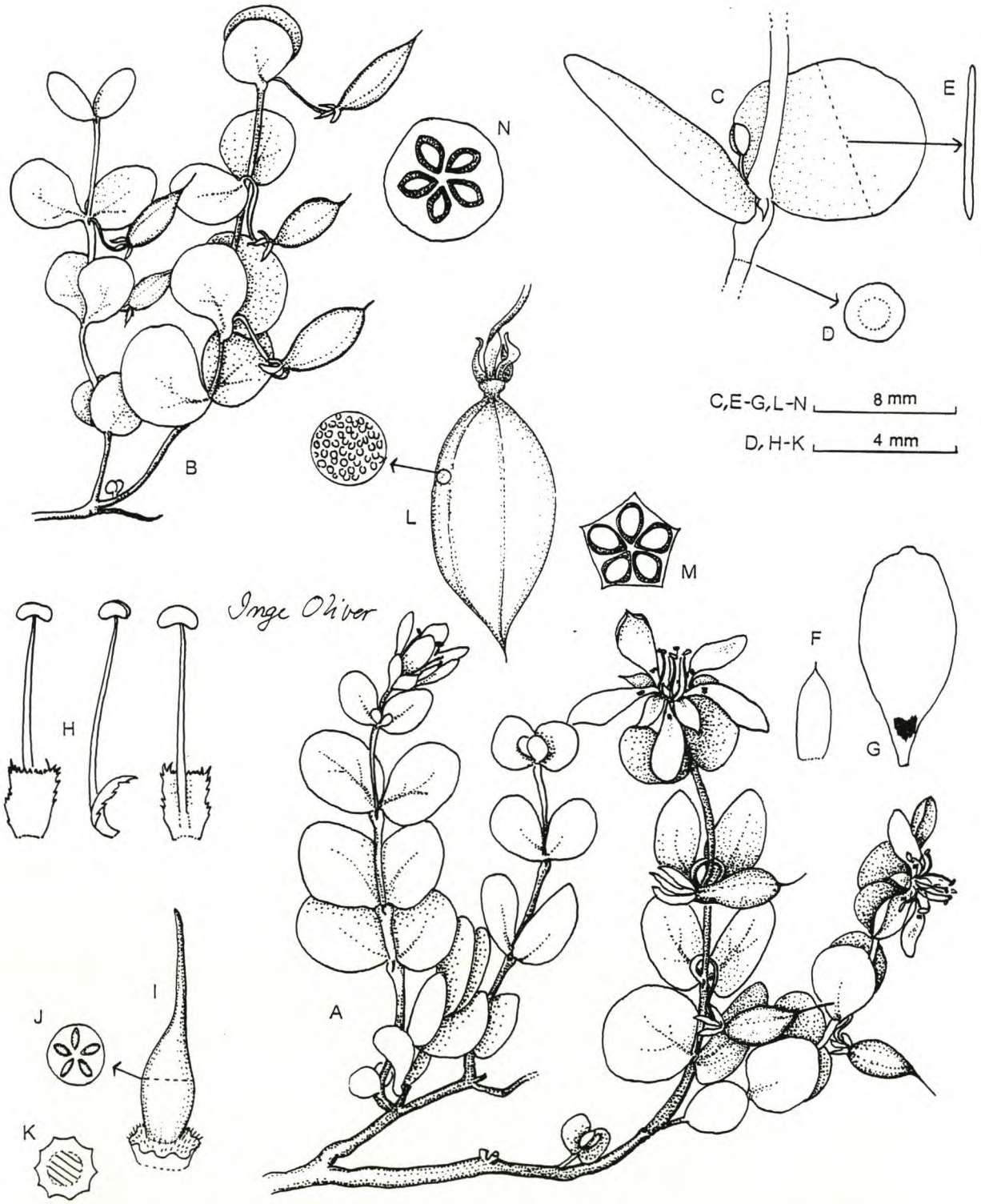
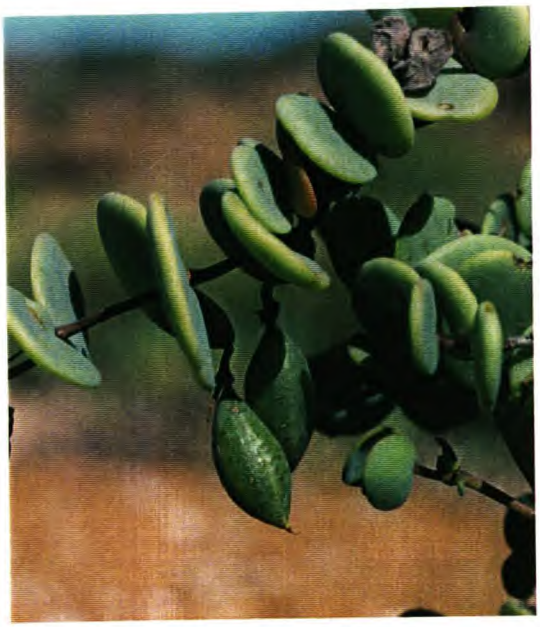


Figure 7.23.1. *Z. fusiforme, Van Zyl 4505*. A—B, flowering and fruiting branches, life-size; C, simple, subrotund leaves; D, cross section of young stem; E, cross section of leaf; F, sepal; G, petal; H, ventral-, side- and dorsal-view of staminal scales; I, ovary situated on papillate, nectar disc; J, cross section of ovary; K, cross section of nectar disc; L, fusiform, succulent, fresh fruit; M, cross section of dry, 5-angled fruit; N, cross section of succulent, fresh fruit.

A



C

B

D

Figure 7.23.2. *Z. fusiforme.* A—C, *Van Zyl 4505*; D, *Van Zyl 4495.* A, open flower with yellow petals, marked at base; B—C, leafy twigs with fresh, succulent, fusiform fruits; D, habit near Eksteensfontein, displaying stems neatly radiating from the center.

Diagnostic characters and affinities

Z. fusiforme is distinguished by its simple, subrotund or widely obovate, succulent leaves with rounded or cuneate, but never cordate base (Figure 7.23.2 A—D), and by its fruits which are soft, succulent and fusiform when fresh (hence the specific epithet) and which becomes ellipsoid, 5-angled, with a wrinkled exocarp when dry. *Z. fusiforme* is allied to *Z. cordifolium* and *Z. orbiculatum,* which have similar, opposite, simple leaves with fleshy, widely obovate or orbicular leaflets. However, some differences occur in the basal part of their leaves. The leaf base of *Z. cordifolium* varies from cordate, obtuse to cuneate, those of *Z. fusiforme* are obtuse or cuneate but never cordate and those of *Z. orbiculatum* are attenuate and contracted into a narrow petiole of 5—10 mm long. These species differ greatly in their fruit morphology. The fruits of *Z. cordifolium* are 10–34 x 9–18 mm in size, oblong, 5-winged with a retuse apex and a thick , strong central body and reticulate-veined wings of 2—5 mm wide. The fruits of *Z. fusiforme* are 15–21 x 5–9 mm in size, fusiform and succulent when fresh (Figure 7.23.2.B—C) and become slightly 5-angled and wrinkled when dry, whereas those of *Z. orbiculatum* are 16–20 x 20–22 mm in size, obovate, 5-winged, with apices retuse, with a flimsy or slender central body and 5 mm wide, reticulate-veined wings. Table 7.7 summarizes the characters of the species in § *Paradoxa*.

Distribution and ecology

Z. fusiforme has a small distribution area which includes the Richtersveld and the adjacent area towards the coast (Figure 7.23.3). It occurs in a vegetation classified as **Succulent Karoo Biome**: Lowland Succulent Karoo and Upland Succulent Karoo (Hoffman 1996). Rain occurs during winter and is low, ranging from 50—300 mm per annum, summers are hot and dry. Soils are derived from granite and gneiss and succulent species, particularly Mesembryanthemaceae, are the dominant, dwarf shrubs present in the vegetation. *Z. fusiforme* occurs as small populations with scattered individuals, or as large populations consisting of hundreds of individuals, including many young plants. In these larger populations, *Z. fusiforme* assumes a dominant

position in the vegetation, resembling *Z. cordifolium* in this aspect. The flowering period starts in late autumn, continues through winter and ends in August. No grazing damage occurs and it can be assumed that this species is not palatable. Although *Z. fusiforme* can occur as large populations, only a few populations in a small area are known, therefore this new species could be considered vulnerable.

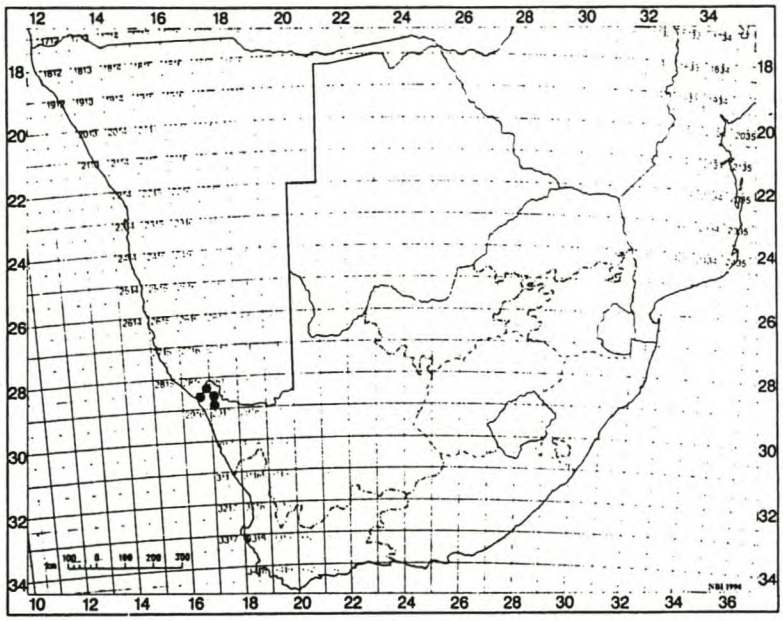


Figure 7.23.3. Geographical distribution of *Z. fusiforme*.

Specimens examined

–2816 (Oranjemund*)*: Sandy flats at base of Cornellskop, Richtersveld (–BD), *Van Zyl 4066* (NBG, PRE); *Van Zyl 4135* (B, BOL, NBG, PRE, S, WIND); *Van Zyl 4505* (NBG, PRE, WIND); Base of Anniskop, Richtersveld (–BD), *Van Zyl 4071, 4498* (BOL, NBG); Steep, S slopes of Anniskop (–BD), *Van Zyl 4139* (NBG, PRE, WIND); Sandy flats along Annisrivier, near Annisfontein (–BD), *Metelerkamp 36* (BOL); Valley floor at N entrance to Helskloof (–BD), *Van Zyl 4503* (BOL, NBG, PRE, WIND); 45 M N of Port Nolloth on road to Alexander Bay (–DA), *Werger 492* (K, PRE).

–2817 (Vioolsdrif): Sandy river course at Eksteensfontein (–CA), *Venter 8052* (PRE); N of Skouerfontein, Eksteensfontein (–CC), *Van Zyl 4060* (NBG); *Van Zyl 4495* (B, BOL, NBG, PRE, S, WIND).

7.24 Zygophyllum orbiculatum *Welw. ex Oliver* in Flora of Tropical Africa 1 : 285 (1868); Welw.: 19–20 (1869); Hiern: 106 (1896); Engl.: 162 (1931);

Huysst.: 67 (1937); Gossweiler & Mendonça: 200—201 (1939); Exell & Mendonça: 1 : 255 (1951); A.Schreib.: 51—53 (1963). TYPE - Angola: Entre Mossâmedes e o Cabo Negro, *Welwitsch 1637* (K, lecto!, designated by Exell & Mendonça, BM!, COI!, LISU).

Erect , many-stemmed, glabrous shrub, reaching a height of 0.5 m and a diameter of 0.6 m. *Stems*: old stems nude, bark smooth, gray, nodes swollen; young stems smooth, pale-green or brown, round in cross section, without ridges or flat areas. *Leaves* opposite, simple, articulate, fleshy, lamina orbicular or obovate-spathulate, 20–50 x 16–60 mm, apex round, base attenuate and contracted in a narrow petiole of 10 mm long; stipules fleshy, navicular, apex obtuse, patent, caducous, one on ventral and one on dorsal side of stem, 6 x 6 mm. *Flowers* 2—3 together, axillary. *Pedicel* 15—18 mm long. *Sepals* 5, ovate, apex obtuse, some with membranous margins, 6 x 4 mm. (The age of herbarium specimens studied as well as the poor condition of flowers caused by insect damage prevented a thorough analysis. I failed to obtain better or fresh material of this species, therefore the flower data related below, and given in italics, might be altered at a later stage) *Petals 5, spathulate, apex obtuse, emarginate, base with a long claw, white, 10–12 x 4–5 mm. Nectar disc fleshy, papillate, 10-angled. Stamens 10; filaments terete, 6—10 mm long; staminal scales 10, simple, oblong or narrowly obovate, apex truncate or v-shaped, upper margins lacerate, 3–6 x 1.5–3 mm, ± ½ the length of the filament. Ovary ovoid, ellipsoid or oblong, 5-lobed with rudimentary wings; style terete, stigma simple. Fruit* a drooping, obovoid, loculicidal capsule, 5-winged, with a slender central body and wide, reticulate-veined wings of ca. 5 mm, apex and base usually retuse, 16–20 x 20–22 mm. *Seed*, no material available for study (Figure 7.24.1).

Diagnostic characters and affinities

Z. orbiculatum is distinguished by its large (20–50 x 16–60 mm in size), simple, orbicular (hence the specific epithet) or widely obovate leaves with the base contracted into a narrow petiole of ca. 10 mm long. It is also distinguished by

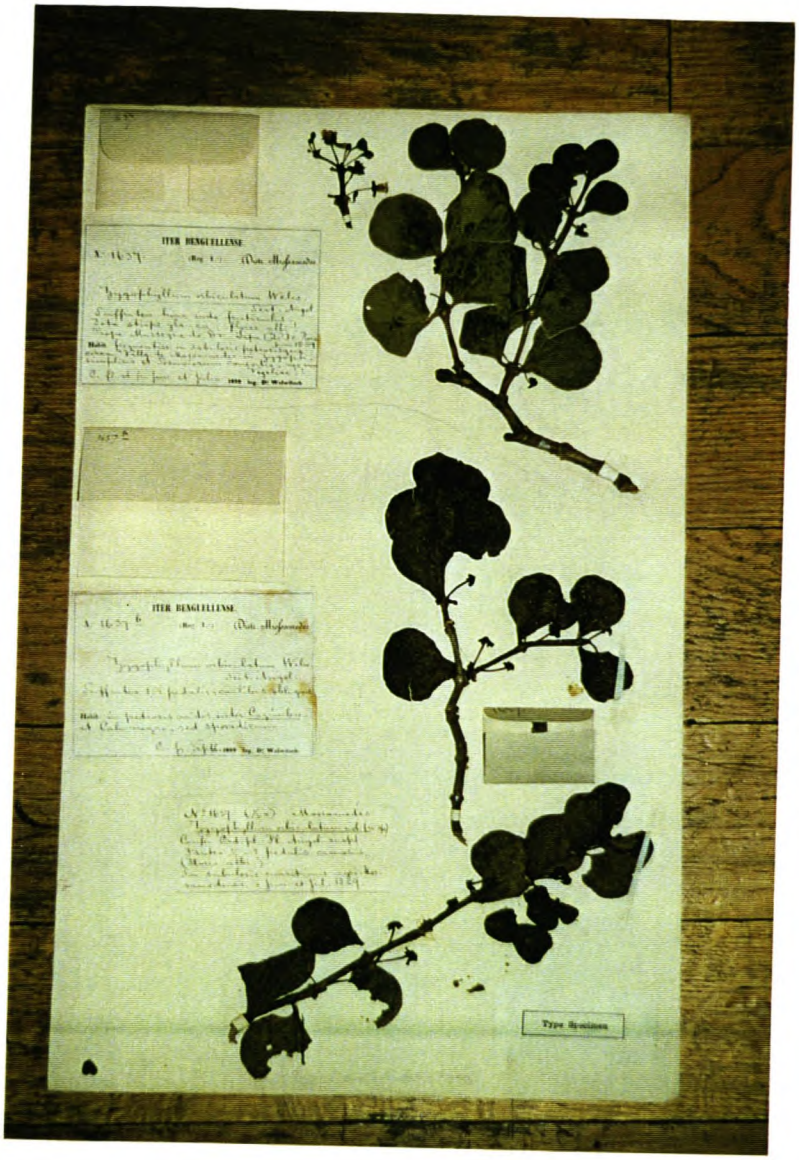


Figure 7.24.1 *Z. orbiculatum*, *Welwitsch 1637*, isotype (BM).

its obovoid, 5-winged, loculicidal capsule, 16–20 x 20–22 mm in size, with the apex and base usually retuse and with a slender central body and wide, reticulate-veined wings of ca. 5 mm. *Z. orbiculatum* is allied to *Z. cordifolium* and *Z. fusiforme* which have similar simple, obovate or orbicular, fleshy leaves. The leaf bases of the latter two species are always sessile and never contracted into a narrow petiole like those of *Z. orbiculatum*. These species differ substantially in their fruit morphology. The fruits of *Z. cordifolium* are oblong, 10–34 x 9–18 mm in size, 5-winged, apices retuse, with a thick, strong central body and articulate-veined wings of 2—5 mm wide. The fruits *Z. fusiforme* are 15–21 x 5–9 mm in size, fusiform when fresh and ellipsoid, 5-angled when dry. The fruits *Z. orbiculatum* are described above. The geographical distribution can be used to distinguish between *Z. orbiculatum*, which has a limited range in southern Angola, and *Z. cordifolium*, which has a northern boundary at Luderitz. *Z. orbiculatum* resembles *Z. stapffii* with regard to fruit and leaf morphology, but the leaves of the latter species are bifoliolate and with regard to floral morphology it belongs to § *Grandifolia*, subgenus *Agrophyllum*. Table 7.7 summarizes the characters of the species in § *Paradoxa*.

According to Schreiber (1963), *Z. orbiculatum* is related to *Z. cordifolium,* because they both have similar, succulent, orbiculate, simple leaves. In my opinion the position of *Z. orbiculatum* is at the present still dubious due to uncertainty about the floral details and to a lack of field work.

Distribution and ecology

Z. orbiculatum occurs in southern Angola. This species was not collected by me and available collectors notes are very scant. Substrates mentioned are sandy areas or amongst rocks, or sand dunes of 20 m. Flowering period is from May to July and fruits are found in September.

Specimens examined

–1511: Entre Mossamedes e o Cabo Negro (–DB), *Welwitsch1637* (BM, COI, K, LISU); *Castro 102* (COI); Porto Alexandre (–DC/DD), *Gossweiler 10833* (BM, COI, K).

–1512: Prox. De Mossamedes (–AA), *Carrisso & Sousa 219* (BM, COI, LISC); 8 km NE of Mossamedes (–AA), *Ward & Ward s.n.* (BM).
–1612: entre o rio Bero e o rio Coroca (–AA/AB), *Exell & Mendonca* 2253 (BM, COI, LISC, LISU); rio Cunene (–AC), *Johnston s.n.* (K).

§ *Capensia* Engl., Uber die geographische Verbreitung....: 14 (1896); Engl. in Engl. & Prantl. 81 (1899); Engl.: 734 (1915); Engl.: 164–165 (1931); Huysst.: 68 (1937).
Type species: *Z. pygmaeum Eckl. & Zeyh.*

Engler (1896) based his description of § *Capensia* on the presence of loculicidal fruits and included ca. 20 species from the south-western Cape and Namibia. Some of the species Engler included in this section are currently included in different sections of subgenus *Agrophyllum* (Engler 1915, 1931). Van Huyssteen (1937) narrowed the concept of § *Capensia* to species with petals with markings at the base, with fimbriate, denticulate staminal scales, ovaries lobed or angled, fruits with endocarp and exocarp sometimes separated, which could be shrubs or shrublets. She divided § *Capensia* into two groups: species with sessile or shortly petiolate leaves and species with petiolate leaves. What follows is my own concept of the diagnostic features of § *Capensia*. A total of 29 species currently belong to this section, nine of which are newly described.

Diagnostic features

Young stems usually with a flat ventral area and prominent lateral ridges
or rhombic, elliptic, without ridges, rarely striate
Leaves opposite, sessile or petiolate, bifoliolate
Some stipules free, some interpetiolar
Petals yellow, marked at base
Nectar disc fleshy, papillate, regularly angled
Staminal scales simple, margins lacerate,
sometimes bordered with papillae
Fruit a loculicidal capsule, variably shaped, without ridges,

ridged or winged

Seed oblong and arillate, testa producing mucilage with long spiral inclusions of a uniform width

The floral and fruit morphology in § *Capensia* is not distinctive and displays no easily recognizable characters along which to divide this rather large group of species. A division according to leaf characters, that are easily recognized, seemed a fair option. Tables 7.8, 7.9 and 7.10 summarize the characters of the species of § *Capensia* as grouped below.

§ *Capensia* is now divided into three groups:

Leaves sessile; leaflets terete or linear (5 species)

Leaves sessile; leaflets obovate, with a flat lamina (12 species)

Leaves petiolate; including two species with leaves either sessile or petiolate (12 species)

Key to the species in § *Capensia* with **sessile, terete or linear leaflets**

1a Leaflets succulent, terete, round in cross section,.....2

1b Leaflets linear, variably grooved on abaxial side.....3

2a Erect, glabrous, woody shrub, leaflets 7–13 mm long, always glabrous, occurring in the Tanqua Karoo..... *Z. botulifolium*

2b Dwarf or decumbent shrublet or scrambler, leaflets 12–45 mm long, hirsute or glabrous, often burgundy coloured, occurring along the west coast and on the Knersvlakte.....*Z. teretifolium*

3a Ventral stipules single with apex sometimes notched, petals yellow of cream coloured.....4

3b Ventral stipules two together, widely diverging, petals always rose pink.....*Z. rogersii*

4a Fruits succulent and with sutures visible when fresh, prominently 5-lobed and ridged when dry, leaflets 10—22 mm long.....*Z. spinosum*

4b Fruits never succulent, 5-lobed and finely ridged when dry, apex usually acute, leaflets 7–14 mm long.....*Z. pygmaeum*

Table 7.8 Characters of the species in § *Capensia* with sessile, terete or linear leaflets.

Z. SPINOSUM	Z. PYGMAEUM	Z. ROGERSII	Z. TERETIFOLIUM	Z. BOTULIFOLIUM
petals yellow or cream, variously marked or red veined	petals yellow, variously marked	**petals rose pink, unmarked**	petals pale yellow, variously marked or unmarked	petals yellow, variously marked
leaflets **linear** with variable abaxial groove 10–22 x 2.0–2.5 mm	leaflets **linear** with variable baxial groove 7–14 x 1.5 x 3.0mm	leaflets **linear** with variable abaxial groove 5–7 x 1 mm	leaflets **terete**, succulent, 12–45 x 2–4	leaflets **terete**, succulent, 7–13 x 2–3
stems flat on ventral side, **with only two lateral ridges**	stems flat on ventral side, **with several ridges**	stems flat on ventral side, **with several ridges**	stems flat on ventral side, **with 2 poorly developed lateral ridges**	stems flat on ventral side, **with 2 poorly developed lateral ridges**
stipules spinescent, one only on ventral side	stipules spinescent, one only on ventral side	stipules spinescent, **two, widely diverging, on ventral side**	stipules not spinescent, one only on ventral side	stipules not spinescent, one only on ventral side
staminal scales lacerate	staminal scales lacerate	staminal scales lacerate	staminal scales **long lacerate, fimbriate**	staminal scales **long lacerate, fimbriate**
loculi 1-seeded	loculi 1-seeded	loculi 1-seeded	**loculi 1—4-seeded**	loculi I-seeded
fruit subspherical, **succulent** and with sutures visible when fresh, 5-lobed and prominently 5-ridged when dry, apex and base btuse, 10–15 x 11–15 mm	fruit subspherical, with apex acute, never succulent, 5-lobed and with 5 weak, thin ridges when dry, apex usually acute, 8–11 x 6–8 mm	fruit subspherical, never succulent, 5-lobed and with 5 weak and thin ridges when dry, 9–10 x 8 mm	fruit oblong, never succulent, 5-lobed and strongly ridged when dry, 12–16 x 10–13	fruit subrotund, not succulent, 5-angled and strongly ridged when dry, 11 x 10 mm

7.25 Zygophyllum teretifolium *Schltr.* in Engl., Botanische Jahrbücher..... 27 : 159 (1900); Huysst.: 73 (1937). TYPE - Western Cape: In lapidosis montium Karreebergen, alt. C. 1000 ped., 24 Jul. 1896, *Schlechter 8303* (BOL!, lecto, designated here, L, PRE!, Z!).

Zygophyllum species	Z. divaricatum	Z. namaqua-num	Z. sessilifolium	Z. spitskop-ensis	Z. cuneifolium	Z. hirticaule
flower colour, marking	yellow, variously marked	yellow, variously marked	white, red-veined	white, red-veined	lime yellow, variously marked	yellow, unmarked
stem shape	flat ventral area, with lateral ridges	rhombic in section, not ridged	flat ventral area, with lateral ridges	flat ventral area, with lateral ridges	flat ventral area, with lateral ridges	flat ventral area, without lateral ridges
stipules on ventral side of stem	two	one only	one only	two	one only	one only
leaflet shape, size in mm	obovate 5–8 x 3.5–4.5	obovate 5–7 x 2–3.5	obovate, margin scabrous 11–20 x 3–8	obovate, cuneate 12–16 x 2–4	cuneate 12–23 x 3.5–4	obovate 20–40 x 13–25
staminal scale type	3	3	4	4	4	4
seeds per locule	1 or 2	1	1	1	1 or 2	1—3
fruit shape	subspheroid 5-lobed 5-ridged	subspheroid 5-lobed 5-ridged	oblong 5-lobed 5-ridged	spheroid/oblong 5-lobed 5-ridged	ovoid 5-lobed 5-ridged	oblong 5-winged
fruit size in mm	8–10 x 6–8	8–12 x 6–8	15–15 x 9	9–12 x 7–9	10–14 x 8–12	13–17 x 11–13

Table 7.9. Characters of the species in § *Capensia* with sessile, usually obovate leaves (not terete or linear), continued on next page.

Zygophyllum species	Z. calcicola	Z. fulvum	Z. porphyro-caule	Z. swartberg-ensis	Z. fuscatum	Z. flexuosum
flower colour, marking	greenish-white or yellowish, red-veined or not	cream, yellow, rarely white, variously marked	yellow, variously marked	yellow, variously marked	yellow, variously marked	yellow, variously marked
stem shape	flat ventral area, with lateral ridges	flat ventral area, with lateral ridges	flat ventral area, with lateral ridges	flat ventral area, with several ridges	flat ventral area, with lateral ridges ending in distinct, acute lobes	flat ventral area, with lateral ridges
stipules on ventral side	one only	two, rarely one only	one only	one only	one only	one only
leaflet shape, size in mm	obovate 13–19 x 4–8	obovate/elliptic 10–30 x 3–15	obovate 10–14 x 3–3	elliptic 12–20 x 3–6	elliptic/obovate 12–16 x 2–5	obovate 11–12 x 3–7
stam. scale type	4	4	4	3	3	3
seeds per locule	1—3	1 or 2	1 or 2	1—4	1–3	1
fruit shape	oblong 5-lobed 5-ridged	oblong/subspheroid vaguely 5-lobed	oblong 5-lobed 5-ridged	oblong 5-lobed 5-ridged	oblong 5-lobed 5-ridged	subspheroid, succulent fresh, 5-angled dry
fruit size in mm	10–13 x 10–13	8–20 x 9–14	9–10 x 8–9	11–15 x 10–12	12–14 x 11–12	8–9 x 9–12

Table 7.9. Characters of the species in § *Capensia* with sessile, usually obovate leaves (not terete or linear), continued from previous page.

Zygophyllum species	Z. lichten-steinianum	Z. incrustatum	Z. maritimum	Z. debile	Z. cretaceum	Z. foetidum
flower colour, markings	yellow, variously marked	yellow, unmarked	yellow, variously marked	yellow, variously marked	yellow, variously marked	yellow, variously marked
stem shape	flat ventral area, with weak lateral ridges	round in section, not ridged	flat ventral area, with lateral ridges	flat ventral area, with lateral ridges	flat ventral area, with several ridges	round/elliptic, not ridged when fresh
stipules on ventral side of stem	one only	one only	two	one only	two	one or two
leaflet shape, size in mm	obovate, asymmetrical 8–17 x 5–6	elliptic 5–7 x 2–3	elliptic/obovate 14–19 x 5–10	ovate/elliptic 11–26 x 4–7	obovate asymmetrical 23–28 x 15–22	obovate asymmetrical 23–28 x 16–30
staminal scale type	3	3	3	3	4	4
seeds per locule	1—3	1	1—4	4—7	1 or 2	1—5
fruit shape	spheroid 5-winged	ovoid 5-lobed 5-ridged	oblong/spheroid sutures visible	oblong 5-winged	subspheroid 5-lobed, not ridged	subspheroid 5-lobed, broadly ridged
fruit size	6–7 x 6–8	9–10 x 6	12–15 x 10–13	12–26 x 9–14	3.5 x 5	8–12 x 6–10

Table 7.10. Characters of the species in § *Capensia* with petiolate leaves (continued on next page).

Zygophyllum species	Z. macrocarpon	Z. maculatum	Z. schreiber-anum	Z. leptopetalum	Z. pubescens petiole/sessile	Z. leucocladum petiole/sessile
flower colour, markings	yellow, variously marked	yellow, variously marked	yellow, variously marked	white, red-veined	yellow, variously marked	yellow, unmarked
stem shape	round, not ridged when fresh	striate, hairy	rhombic in section, hairy	elliptic, striate, hairy	elliptic, striate, hairy, rarely glabrous	flat on ventral side, with lateral ridges
stipules on ventral side of stem	one	one	one, alternately biparted	one, rarely two	one	one
leaflet shape size in mm	obovate asymmetrical 35–50 x 30—45	linear, narrowly obovate 6–13 x 1.5–2	terete, trifolilate	obovate asymmetrical 17–25 x 10–17	obovate/elliptic 7–20 x 2–5	obovate/elliptic 7–12 x 2–5
staminal scale type	4	1, sometimes notched	4	4	3	3
seeds per locule	10—16	1—3	1 or 2	1 or 2	1 or 2	1 or 2
fruit shape	prismatic, 5-winged	oblong 5-lobed 5-ridged	subspheroid 5-lobed 5-rodged	subspheroid 5-lobed, broadly ridged	subspheroid 5-lobed 5-ridged	ovoid/oblong 5-lobed 5-ridged
fruit size in mm	25–43 x 15–20	12–13 x 7—8	7–8 x 7–8	7–13 x 7—12	8–9 x 5–8	5–13 x 4

Table 7.10. Characters of the species in § *Capensia* with petiolate leaves (continued from previous page).

Decumbent, dwarf shrublet, or lax, scrambling shrub, reaching a height of (0.05–)0.3(–1.3) m and a diameter of (0.2–)0.7 m. *Stems*: old stems nude, bark dark grey, nodes swollen; young stems green, leafy, smooth, flat on ventral side and with poorly developed lateral ridges. *Leaves* opposite, sessile, bifoliolate; rachis apex triangular, brown, reflexed; leaflets glabrous or hirsute, becoming glabrescent with age, articulate, terete, succulent, grooved on both adaxial and abaxial sides, dark green, sunny side often tinted burgundy,12–45 x 2–4 mm, apex and base obtuse; stipules widely triangular, one on ventral side, sometimes shallowly notched, and one on dorsal side of stems, 1.0–2.5 x 2.5–3.0 mm. *Flowers* one or two together, axillary. *Pedicel* hirsute, 10—25 mm long, recurved, changing colour to burgundy and elongating in fruit to 45 mm. *Sepals* 5, ovate, green, glabrous or sparsely hirsute on dorsal side, in fruit burgundy coloured, 7–15 x 3–5 mm. *Petals* 5, ovate or elliptic, 14–21 x 6–7 mm, apex obtuse or acute, base with a short claw, pale yellow, variously marked at base with M- or V-shaped blotches and streaky bands in deeper yellow, brown or red or without any markings. *Nectar disc* fleshy, papillate, regularly 10-angled. *Stamens* 10; filaments terete, 7—9 mm long; staminal scales 10, simple, oblong, upper margins long lacerate, apex obtuse or acute, 3–5 x 1.5–2 mm; ± ½ as long as filament. *Ovary* ellipsoid, 5-lobed; style terete; stigma simple. *Fruit* an oblong, drooping, burgundy coloured, 5-lobed, loculicidal capsule, each lobe with a strong, central ridge that is slightly wider at the apex of fruit than at its base, 12–16 x 10–13 mm. *Seed* oblong, 1–4 per loculi, 5–6 x 2–3 mm, dark brown with a white aril, testa smooth, glossy, producing light brown, structured mucilage with long, spiral inclusions of uniform width when wet (Figures 3.9.N—O; 7.25.1).

Diagnostic characters and affinities

Z. teretifolium is recognised by its sessile, bifoliolate leaves with succulent, terete, leaflets (hence the specific epithet), by its staminal scales with long, lacerated upper margins, by its hirsute pedicels and by its mature fruits that are burgundy coloured, 5-lobed and ridged (Figure 7.25.1 B). It is allied to *Z. botulifolium*. They have similar sessile leaves with terete leaflets, those of *Z. teretifolium* 12–45 x 2–4 mm in size, grooved on both sides and usually hirsute and those of *Z. botulifolium* always

Figure 7.25.1. *Z. teretifolium*, A—C, *Van Zyl 3951*; D, *Van Zyl 4007*. A, flower with yellow petals, marked at the base; B, drooping, burgundy coloured fruits; C, dwarf habit on the quartz pebble patches on the Knersvlakte; D, scrambling habit near Landplaas.

glabrous and smaller, 7–13 x 2–3 mm in size. They both have a flat ventral area and poorly developed lateral ridges on their young stems, and a similar number of triangular stipules on their stems. Their fruits are similar in shape, but differ in colour, those of *Z. teretifolium* burgundy coloured, those of *Z. botulifolium* greenish. Their leaf anatomy reveal a similar type of tissue arrangement, those of *Z. teretifolium* inclined to a centric pattern and those of *Z. botulifolium* to a cylindrical type (Kuun 1997). Although they both occur in the Lowland Succulent Karoo Biome (Hoffman 1996), their distributions differ with *Z. teretifolium* occurring along the west coast in Namaqualand and *Z. botulifolium* occurring inland in the Tanqua Karoo. Table 7.8 summarizes the characters of the species in § *Capensia* with sessile, terete or linear leaflets.

Distribution and habitat:

Z. teretifolium is found on the extremely arid Knersvlakte in the Vanrhynsdorp District in the Western Cape and the adjacent, low lying, coastal areas towards Landplaas and Kotzerus (Figure 7.25.2). It occurs in a vegetation classified as **Succulent Karoo Biome**: Lowland Succulent Karoo (Hoffman 1996), which represents an extremely arid vegetation type. Soils are rich and derived from decaying granite and gneiss, but towards the coast sands are predominant. Rainfall occurs during winter months, are predictable and generally quite low, ranging from 50 to 200 mm per annum with hot and dry summers. According to Hoffman (1996), the predictable winter rains enhance the presence of succulent shrubs, especially those that store water in their leaves like *Z. teretifolium*. On the extremely arid Knersvlakte, small populations of *Z. teretifolium* occur on quartz pebble patches where it assumes dwarf proportions, 0.05 m in height and 0.2 m in diameter (Figure 7.25.1.C), with leaves glabrous and burgundy coloured. Here populations are small and are listed as rare and endemic (Hilton-Taylor 1996). However, in recently discovered populations closer to the coast in the Landplaas area and further north which experience less extreme conditions, populations and individuals are larger in size and numbers, greener and usually hirsute, consisting of many scattered individuals, some of which scramble into neighbouring plants, reaching heights of 1.3 m (Figure 7.25.1.D). Grazing damage occurs, but is not excessive. In contrast to the small

populations on the Knersvlakte, the numerous and larger populations closer to the coast seem not to be threatened at present. Flowering occurs from June to July and fruits are found from late July to September.

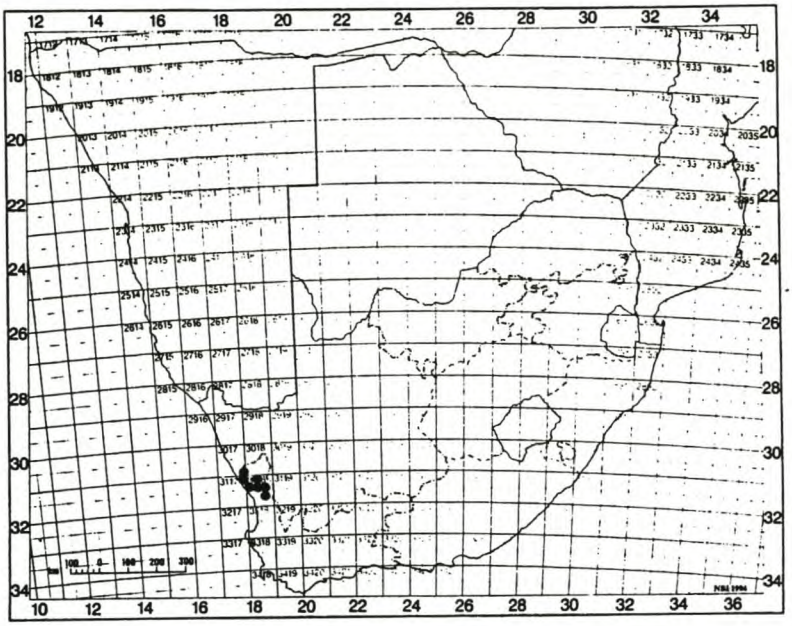


Figure 7.25.2. Geographical distribution of *Z. teretifolium*.

Specimens examined

–3017 (Hondeklipbaai): 10 km N of Kotzesrus on road to Garies (–DD), *Van Zyl 4373* (NBG).
–3117 (Lepelfontein): Granite outcrops S of Kotzesrus (–BB), *Van Zyl 4372* (NBG, PRE).
–3118 (Vanrhynsdorp): Kareebergen (–AB), *Schlechter 8303* (BOL, PRE, Z); Kwaggaskop, N of Vanrhynsdorp (–AB), *Van Zyl 3951* (NBG); 2 km N of Landplaas turn off (–AC), *Van Zyl 4367* (BOL, NBG); Landplaas turn off to Rooivlei (–AC), *Van Zyl 4007* (BOL, GRA, NBG, PRE, WIND); Reddish loam soil on Witvlei, near Landplaas (–AC), *Van Zyl 4143* (NBG, PRE); S of Kliphoek Stasie, near Koekenaap (–AD), *Van Zyl 4144* (BOL, NBG); Bruinkoppies, 7.5 km N of Koekenaap (–AD), *Van Zyl 4365* (NBG, PRE); Holrivier, 17 M N of Vredendal (–AD), *Hall 3643* (NBG); Moedverloor, Holrivier (–AD), *Van Jaarsveld 11793* (PRE); Kwaggaskop, ± 20 km N of Vanrhynsdorp (–BC), *Bayer & Van Jaarsveld s.n.* (NBG 113374); *Van Jaarsveld 6816* (NBG); On Knersvlakte, 5 km W of Soutrivier bridge (–BC), *Oliver, Tölken & Venter 839* (NBG, PRE); Arizona, N of Vanrhynsdorp (–BC), *Van Zyl 3954* (NBG); *Van Zyl 4033* (NBG); *Van Zyl 4016* (BOL, GRA, NBG, PRE); *Van Zyl 4117* (NBG, PRE); Between Knersvlakte and Sandveld (–BC), *Leipoldt 4037* (BOL); In quarts pebbles, 3 km from N7 on Dous the Glim road (–BC), *Van Zyl 3998* (BOL, NBG); Knersvlakte, 1 M S of Goeie Hoop on road to Arizona (–DA), *Jordaan 1226* (NBG).

7.26 Zygophyllum botulifolium *Van Zyl* in Van Zyl & Marais, Bothalia 27,2: 131 (1997). TYPE - Western Cape: Doornrivier crossing between Ceres and Sutherland, *Van Zyl 3935* (NBG!, holo, B!, BOL!, PRE!, S!, WIND!).

Erect, many-stemmed, woody shrub, reaching a height of 0.6 m and a diameter of 0.6 m. *Stems*: old stems woody, resprouting at lower nodes, bark dark grey; young stems green, flat on ventral side and with poorly developed lateral ridges. *Leaves* opposite, sessile, bifoliolate, dark green, sometimes with brown tints; rachis apex triangular, membranous, caducous, 1 x 1 mm; leaflets articulate, terete, succulent, not grooved, apex and base obtuse, 7–13 x 2–3 mm; stipules triangular, membranous, caducous, one on ventral and one on dorsal side of stems, 1 x 1.5 mm. *Flowers* solitary, axillary. *Pedicel* 7—10 mm long. *Sepals* 5, ovate or oblong, apex acute or obtuse, some with membranous margins, 7–8 x 3 mm. *Petals* 5, elliptic or subrotund, apex obtuse or acute, base with a short claw, sulfur yellow or golden yellow, variously marked at base in red, brown or khaki in vague T-shapes or tiered bands, 9–11 x 4–5 mm. *Nectar disc* fleshy, papillate, regularly 10-angled. *Stamens* 10; filaments terete, 5–7 mm; staminal scales simple, oblong or obovate, upper margins long lacerate or fimbriate, 3.0–4.0 x 1.0–1.5 mm, ± ½ the length of the filament. *Ovary* ovoid, 5-angled; style terete, stigma simple. *Fruit* a subrotund, 5-angled and 5-ridged, loculicidal capsule, 11 x 10 mm. *Seed* oblong, 1 per locule, 4.0 x 2.5 mm, white aril present, testa smooth, glossy, producing structured mucilage with long spiral inclusions of uniform width when wet(Figure 7.26.1).

Diagnostic characters and affinities

Z. botulifolium is distinguished by its sessile, bifoliolate leaves with succulent, terete, leaflets (hence the specific epithet; Figure 7.26.2.B), by its staminal scales with long lacerated upper margins (Figure 7.26.2.A) and by its subspheroid, 5-lobed and 5-ridged capsules. It is allied to *Z. teretifolium* which displays a similar leaf, flower and fruit morphology. Both species have sessile, bifoliolate leaves with succulent, terete leaflets, those of *Z. botulifolium* are always glabrous and the smallest, 7–13 x 2–3 mm in size, those of *Z. teretifolium* are 12–45 x 2–4 mm in size and usually hirsute. They also have similar staminal scales and a similar filament to staminal scale ratio

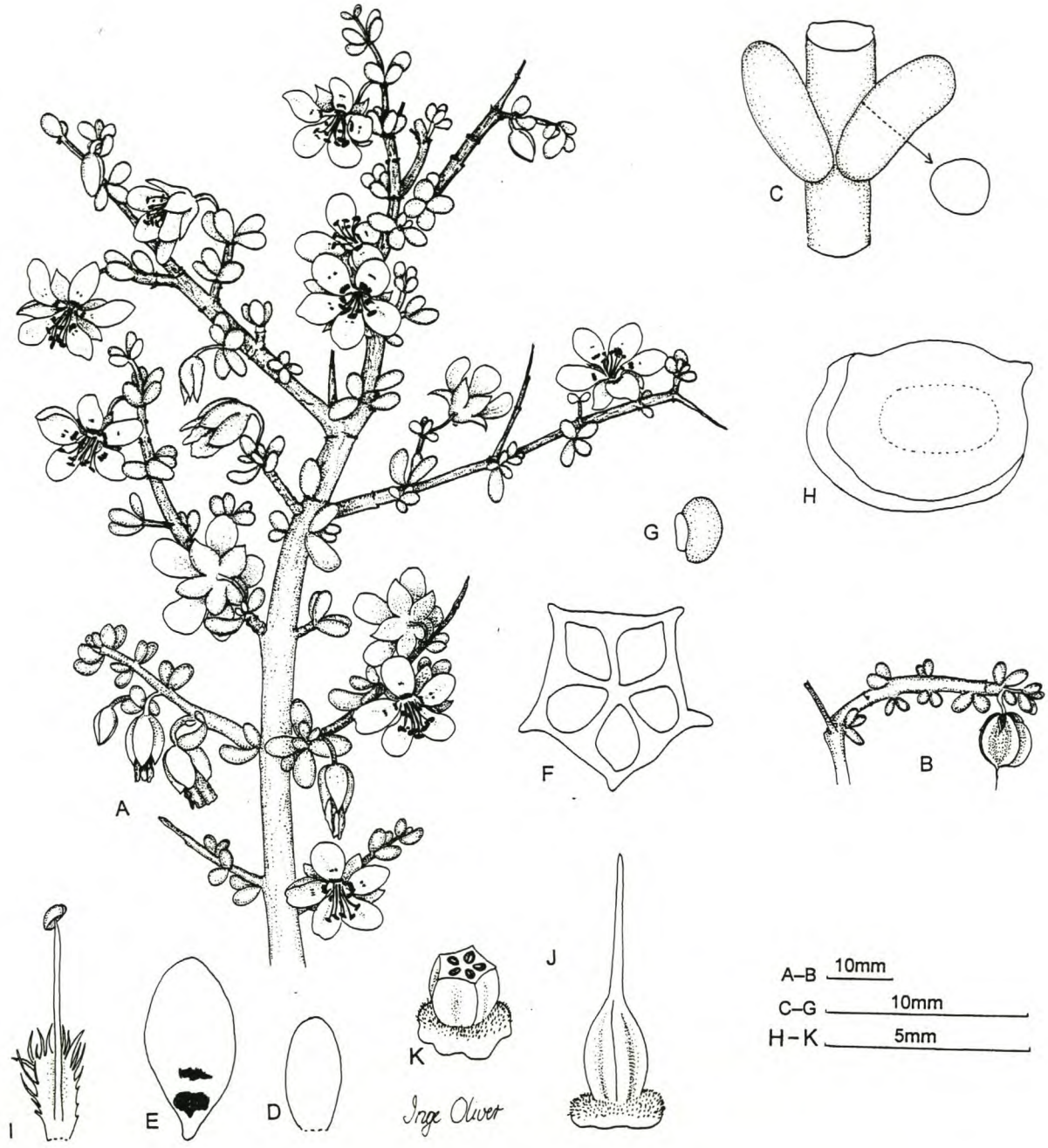
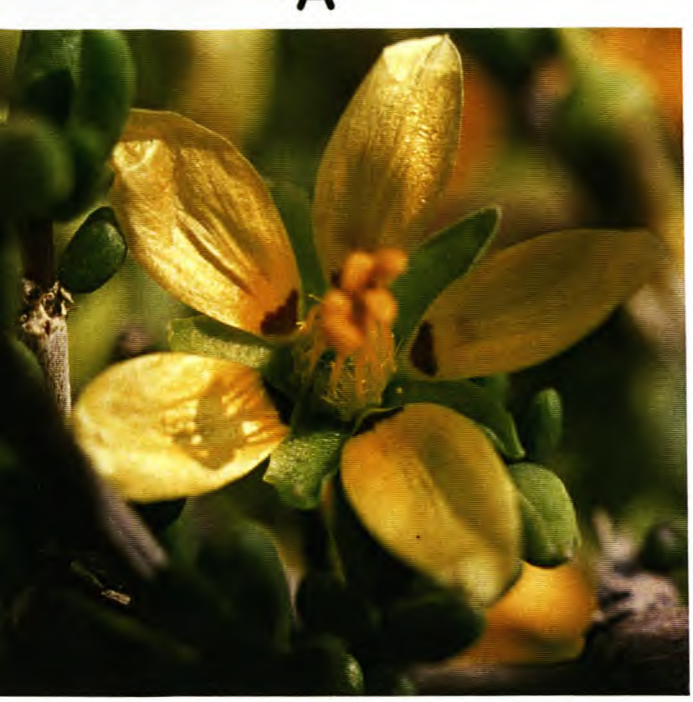


Figure 7.26.1. *Z. botulifolium, Van Zyl 3935.* A, flowering branch; B, fruiting branch; C, leaflets with cross section; D, sepal; E, petal; F, cross section of fruit; G, seed with aril; H, cross section of young stem; I, dorsal view of staminal scale; J, ovary on papillate nectar disc; K, cross section of ovary.



C

D

Figure 7.26.2. *Z. botulifolium, Van Zyl 4237.* A, yellow petals with T-shaped markings at base and long fimbria on staminal scales clearly showing in throat of flower; B, twigs with succulent, terete leaflets; C. a well grazed shrub; D, habit in the Tanqua Karoo.

of 2 : 1. Their habits differ largely with *Z. botulifolium* an erect, woody shrub (Figure 7.26.2.D) and *Z. teretifolium* a decumbent shrublet or sometimes a scrambler reaching into other plants. Although both species occur in the Lowland Succulent Karoo Biome (Hoffman 1996) their distributions differ with *Z. botulifolium* found in the much harsher conditions of the Tanqua Karoo and *Z. teretifolium* occurring in the milder climate along the west coast in Namaqualand. Their different habitats probably cause the difference in their habits. Table 7.8 summarizes the characters of the species in § *Capensia* with sessile, terete leaflets.

Distribution and habitat

Z. botulifolium occurs in the southern part of the Tanqua Karoo (Figure 7.26.3) in a vegetation classified as **Succulent Karoo Biome**: Lowland Succulent Karoo (Hoffman 1996), which represents an extremely arid vegetation type. This vegetation type has a high succulent species diversity, especially consisting of those succulents which, like *Z. botulifolium,* store water in their leaves,. In the Tanqua Karoo the substrate is derived from Karoo Sequence shales and sandstones which give rise to skeletal soils. The terrain is flat to gently undulating and is often overlain with loose rocks where *Z. botulifolium* occurs. Summers are dry and hot, winters cold with extremely low winter rainfall of 50—100 mm per annum. In a sterile state *Z. botulifolium* may be mistaken for a vygie bush (Mesembryanthemaceae) because of its succulent, terete leaflets. Grazing damage is extreme (Figure 7.26.2.C). *Z. botulifolium* is a popular fodder and its total range lies within sheep farming areas, which probably explains the rarity of seedlings or young plants. Because of the small size of populations, few populations and grazing pressure, *Z. botulifolium* is considered vulnerable. Flowering period is from July to August, while fruits are found until September.

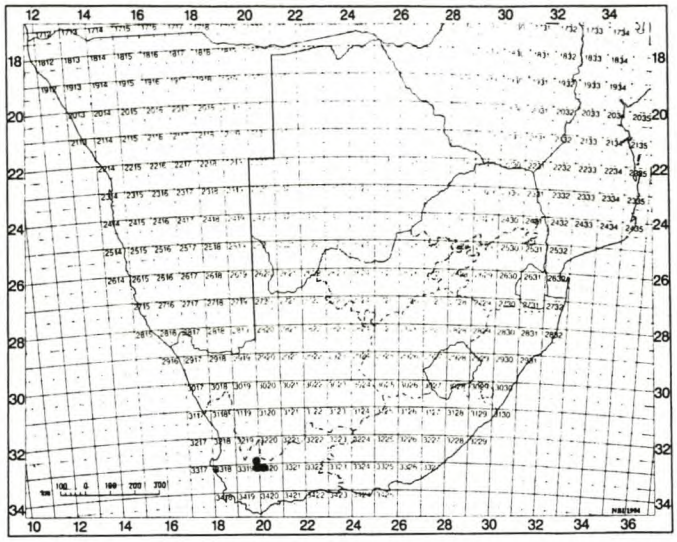


Figure 7.26.3. Geographical distribution of Z. botulifolium.

Specimens examined

–3219 (Wuppertal): Grootrivierloop at Soutpanskoppies, Ceres Karoo (-DD), *Van Zyl 4200* (NBG, PRE).

–3319 (Worcester): Doornrivier crossing between Ceres and Sutherland (-BB), *Van Zyl 3935* (B, BOL, NBG, PRE, S); Between Inverdoorn and Tweeriviere, Ceres Karoo (-BB), *Van Zyl 4238.*

–3320 (Montagu): Between Toorberg and Perdekraal (-AA), *Van Zyl 4135* (NBG, PRE).

7.27 Zygophyllum spinosum *L.*, Species plantarum: 386 (1753); L.: 380 (1767); Burm. f.: 12 (1768); Thunb.: 80 (1794); Willd.: 563 (1799); Pers.: 463 (1806); Thunb.: 544 (1823); DC.: 706 (1824); Don: 772 (1831); Eckl. & Zeyh.: 98 (1835); Sond.: 358 (1860); Huysst.: 70 (1937); Adamson & Salter: 534 (1950); Batten & Bokelmann: 9 (1966); Mason: 140 (1972); Bond & Goldblatt: 437 (1984). ICONOTYPE - Burmann, Rariorum africanorum plantarum: 4 t. 2, f.2 (1738).

Zygophyllum procumbens *Adamson*: 207 (1941); Adamson & Salter: 534: (1950). TYPE - Western Cape: Vasco da Gama Peak, Cape Peninsula, *Adamson 2889* (BOL!, holo).

Zygophylum pallidum *Schltr.* In arenosis, Piekenierskloof, 28 June 1896, *Schlechter 7933* (S!, Z!); nom nud.

Erect or decumbent, many-stemmed, slender shrublet or woody shrub, reaching a height of 1.0 m and a diameter of 1.5 m, but smaller towards its southern boundary on the Cape Peninsula. *Stems*: old stems nude, bark rough, light or dark gray, cracked; young stems brownish, smooth, flat on ventral side, with prominent lateral ridges and several, less prominent, dorsal ridges. *Leaves* opposite, sessile, bifoliolate; rachis apex triangular, brownish, reflexed, base thickened, spinescent, 0.5–1 x 0.5–1 mm; leaflets articulate, green or glaucous, linear, with an abaxial groove of varying depth and width, margins recurved, often succulent with age, and the groove then absent, 10–22 x 2–2.5 mm, apex mucronate in juvenile stage, obtuse with age, base obtuse; stipules brown, stiff, reflexed, base thickened, spinescent, one on ventral side notched at apex, and one on dorsal side of stems, 1 x 1–2 mm. *Flowers* solitary or sometimes 2 together, axillary. *Pedicel* 8—24 mm long. *Sepals* 5, ovate, obovate or subrotund, apex rounded, some with membranous margins, 4–6 x 3–6 mm. *Petals* 5, widely obovate, apex rounded, often emarginate, base with a short claw, cream coloured or yellow, marked at base with a maroon blotch and streaked with maroon veins of variable length which sometimes reach to the petal margins, or without maroon veins or completely unmarked, 9–14 x 6–9 mm. *Nectar disc* fleshy, papillate, regularly 10-angled. *Stamens* 10; filaments terete, 6—8 mm long; staminal scales 10, simple, oblong or narrowly obovate, apex obtuse, upper margins finely lacerate, 2–3 x 1.5–2 mm, ± 1/3 the length of the filament. *Ovary* spheroid, with sutures visible; style terete; stigma simple. *Fruit* a drooping, loculicidal capsule; when fresh, spheroid, succulent and with visible sutures, tinted pink or maroon on sunny side, apex and base obtuse; when dry, prominently 5-lobed, each lobe with a central ridge where splitting will occur, 10–15 x 11–15 mm. *Seed* oblong, 1 per locule, 6.0–7.0 x 2.5–3.0 mm, dark brown with a white aril, testa glossy, smooth, producing structured mucilage with long spiral inclusions of uniform width when wet (Figure 7.27.1).

Diagnostic characters and affinities

Z. spinosum is recognized by its sessile, bifoliolate leaves with linear leaflets which are grooved on abaxial side (Figure 7.27.1.D), by its reflexed, spinescent stipules

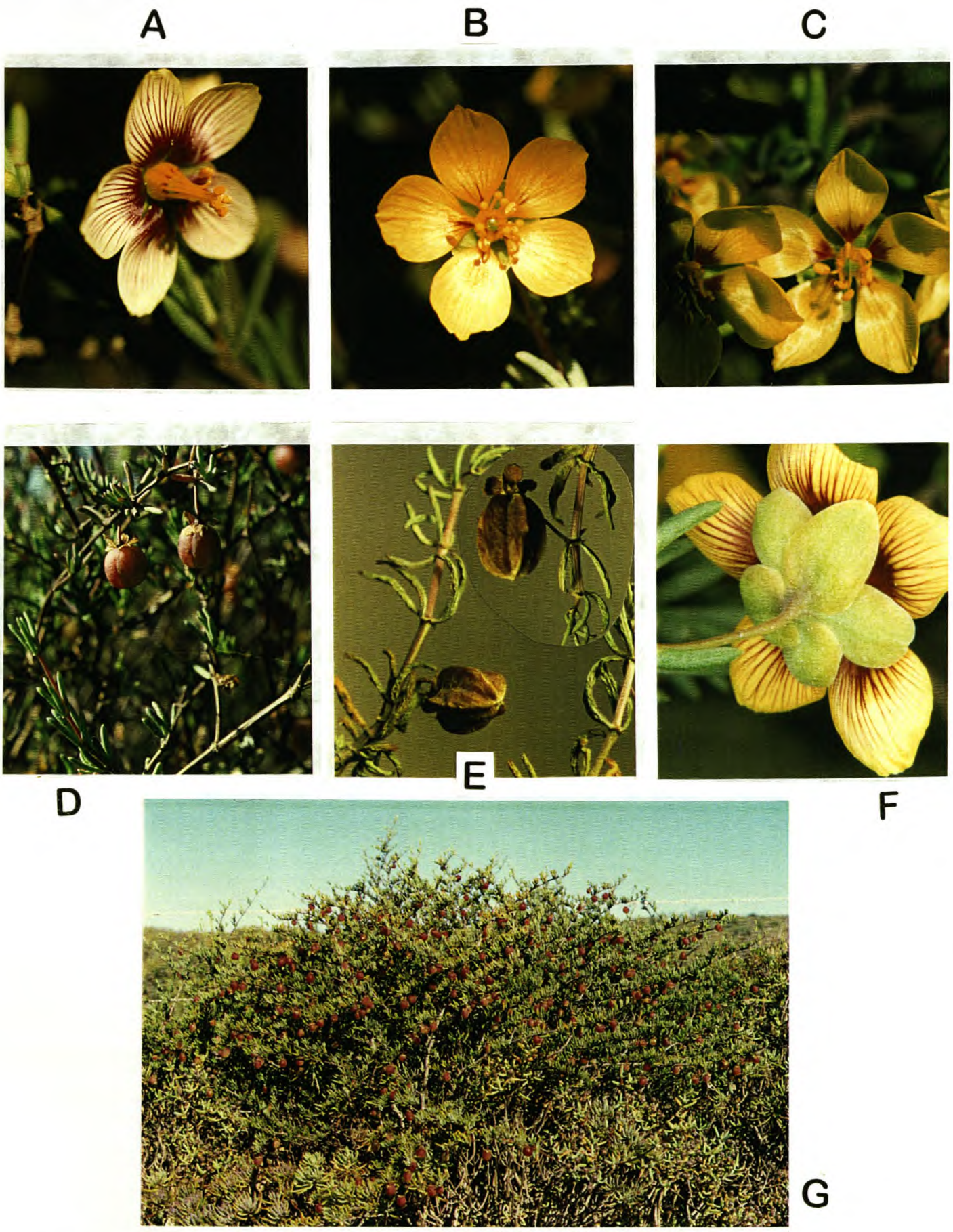


Figure 7.27.1. *Z. spinosum*, A—C, variation in flower colour and markings. A, *Van Zyl 4250*; B, *Van Zyl 4249*; C, *Van Zyl 4018*; D, succulent, spheroid, fresh fruits with visible sutures, *Van Zyl 3963*; E, prominently 5-lobed and ridged dry fruits, *Van Zyl 4123*; F, back-view of flower displaying sepals with rounded apices, *Van Zyl 4227*; G, robust habit in its northern range near Elandsbaai, *Van Zyl 3964*.

and similar but slightly longer rachis apices (hence the specific epithet), by its spherical fruits which are succulent when fresh (Figure 7.27.1.D,G), becoming prominently 5-lobed and ridged when dry, and which have an obtuse apex and base (Figure 7.27.1.E). *Z. spinosum* is closely allied to *Z. pygmaeum* and *Z. rogersii* which have similar leaf and floral morphologies. All three species have linear, grooved leaflets, but with different dimensions. The leaflets of *Z. spinosum* are the largest, 10.0–2.2 x 2.0–2.5 mm in size, those of *Z. pygmaeum* are 7.0–14.0 x 1.5–3.0 mm in size and those of *Z. rogersii* are the smallest, 5–7 x 1 mm in size. *Z. rogersii* is distinguished by its rose coloured petals. The petals of *Z. spinosum* are cream or pale to deep yellow, unmarked or variously marked at the base with a maroon blotch. Thin, maroon veins run from this blotch either half way to or all the way to the margins of petals or are absent. Petals covered with maroon veins sometimes appear totally suffused with pink in the dry state, resembling the rose coloured petals of *Z. rogersii*. The petals of *Z. pygmaeum* are pale or bright yellow, variously marked at base with darker yellow and with red or reddish-brown M-shaped single or tiered figures or in shapeless blotches. The main difference between *Z. spinosum* and *Z. pygmaeum* lies in their different leaf sizes, in the absence of succulence in the fresh fruit of *Z. pygmaeum*, and in the acute apex of the dry fruit of *Z. pygmaeum*. Table 7.8 summarizes the characters of the species in § *Capensia* with have sessile, bifoliolate leaves with terete or linear leaflets.

Distribution and ecology

Z. spinosum is found along the west coast of South Africa, from Hondeklipbaai in the north towards the Cape Peninsula in the south. A single collection was made at Groot Hangklip Mountain on the eastern side of False Bay (Figure 7.27.2). It occurs in a vegetation classified as **Succulent Karoo Biome**: Strandveld Succulent Karoo, Upland Succulent Karoo and Lowland Succulent Karoo (Hoffman 1996) and in **Fynbos Biome**: Mountain Fynbos and Sand Plain Fynbos (Rebelo 1996). Both these Biomes experience dry, hot summers and receive rain during winter months, with a precipitation range of 50—300 mm per year in the Succulent Karoo and 200—2000 mm per year in the Fynbos Biome. In the Succulent Karoo substrates develop from Quaternary sands along the coast and from Karoo Sequence shale and

sandstone further inland. In the Fynbos Biome soils are derived from sandstone of the Cape Supergroup as well as acid sands mostly of Tertiary origin. *Z. spinosum* has a robust and erect habit in the northern part of its range in a dry and harsh climate with a sparse and open vegetation. In its southern range on the Peninsula, where a milder climate with higher rainfall is experienced, *Z. spinosum* has a procumbent habit. It is inclined to be hidden under and amongst the larger shrubs in the denser and taller vegetation. This difference in habit led to the description of *Z. procumbens* (Adamson 1941). However, this seems to be without any significant morphological basis and *Z. procumbens* is now placed in the synonymy of *Z. spinosum*.

Flowering occurs from June to September and fruits are found until December. As with other *Zygophyllum* species, the succulent nature of the fruits causes a delay in their shedding. Populations are dispersed over large areas and consist of scattered individuals and rarely with juveniles and seedlings. Grazing damage occurs, but not to the same extent as in the closely related *Z. pygmaeum*. The northern range of *Z. spinosum* falls within sheep farming and wheat and potato producing areas and there is a great demand for further agricultural development of the natural habitat of *Z. spinosum*. In the Cape Peninsula its habitat is also disappearing under land development schemes. This could have a negative impact on the future stability of populations, however, at present this species is not threatened.

Common name: Kleinskilpadbos.

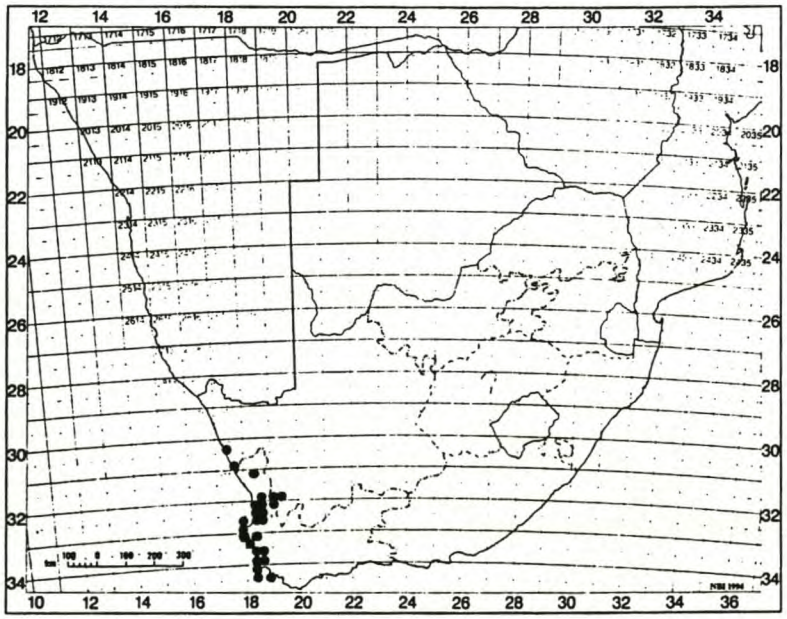


Figure 7.27.2. Geographical distribution of *Z. spinosum*.

Specimens examined

–3017 (Hondeklipbaai): Near Hondeklipbaai (–AD), *Verdoorn & Dyer 1798* (PRE); Diknek, near the coast (–AD), *Van Breda 4066* (PRE); 3 M N of Wallekraal (–BC), *Acocks 14931* (PRE); Dunes N of Groenrivier mouth (–DC), *Le Roux & Ramsey 291* (NBG, PRE).

–3118 (Vanrhynsdorp): Nuwerust (–AB), *Barker 5709* (NBG); Near Klawer (–DC), *Compton 20694* (NBG); Skilpadrust, near Heerenlogement National Monument (–DC), *Van Zyl 3663* (BOL, NBG, PRE); Sandy flats between Driefontein and Heerenlogement National Monument (–DC), *Pearson 6783* (BOL).

–3119 (Calvinia): Vryheid, 80 km SW of Calvinia (–CC), *Van Wyk s.n.* (PRE 58431); Top of Botterkloofpas (–CD), *Maguire 1898* (NBG).

–3217 (Vredenburg): Above Stompneus (–DB), *Booysen 143* (NBG); Between Saldanha and Vredenburg (–DD), *Leighton 1785* (BOL).

–3218 (Clanwilliam): Nortier experimental farm near Lamberts Bay (–AB), *Van Breda 4346* (PRE); *Boucher 2582* (NBG, PRE); *Barnard s.n.* (NBG); *Van der Merwe 1750* (NBG); Zuurfontein (–AB), *Schlechter 8552* (BOL); Wadrif Soutpan, coastal side of railway (–AB), *O'Callaghan, Van Wyk & Morley 91* (NBG); Roadside on Koopmansdrif, Elandsbaai (–AD), *Van Zyl 4227* (BOL, NBG, PRE); Westerwal, N of Dwarskersbos (–AD), *Van Zyl 4250, 4251, 4513* (NBG); 11 km W of Redelinghuys (–AD), *Van Zyl 4249* (BOL, NBG, PRE); Near Redelinghuys (–AD), *Lewis 2942* (SAM): Hills on S side of Verlorenvlei, near Elandsbaai (–AD), *Van Zyl 4018, 4123* (BOL, NBG, PRE); Hills on N side of Verlorenvlei, near Elandsbaai (–AD), *Van Zyl 4022* (BOL, NBG, PRE); Kliphoutkop, NE of Elandsbaai (–AD), *Van Zyl 4230* (BOL, NBG, PRE); Hills NE of Elandsbaai (–AD), *Van Zyl 3964* (NBG, PRE); 3.5 M NE of Graafwater (–BA), *Acocks 19663* (PRE); Between Graafwater and Clanwilliam (–BA/BB), *Bolus s.n.* (BOL 23231); Road shoulders on SE side of Redelinghuys (–BC), *Van Zyl 4024* (BOL, GRA, NBG, PRE, S); 5 km W of Redelinghuys (–BC), *Van Zyl 4363* (NBG); Between Redelinghuys and Die Grip (–BC), *Van Zyl 4193, 4222* (NBG, PRE); NE corner of Rocher Pan Nature Reserve (–CB), *Le Roux & Ramsey 20* (NBG); Near Aurora (–CB), *Van Zyl 4019* (BOL, NBG); Palmietvlei, between Redelinghuys and Ezelsfontein (–DA), *Barker 9702* (NBG).

–3219 (Wuppertal): Driefontein, 4 km SW of Doringbos on Botterkloofpas road (–AA), *Hilton-Taylor 1845* (NBG).

–3317 (Saldanha): Hills above Saldanha (–BB), *Pamphlett 69* (NBG); Flats behind Hoedtjiespunt (–BB), *Barker 10234* (NBG).

–3318 (Cape Town): In sand near Hopefield (–AB), *Bolus 12626* (BOL); Between Bergrivier and Hopefield (–AB), *Leighton 623* (BOL); Waterboerskraal, Hopefield (–AB), *Van Zyl 3609* (NBG); Koperfontein (–AB), *Barker 8061* (NBG); Near Yzerfontein (–AC), *Compton 7798* (NBG); Mamre road (–CB), *Compton 19860* (NBG); *Stokoe s.n.* (SAM 63616); 10 M S of Mamre (–CB), *Wilman 654* (BOL); Katzenberg Hill (–CB/DA), *Dickson s.n.* (NBG 7552); Sandy flats between Paardeneiland and Blauwberg (–CD), *Drege 7171* (PRE); Milnerton (–CD), *Barker 1472* (NBG); Burgerspost, near Pella (–DA), *Boucher & Shepherd 4516, 4598* (NBG, PRE); 26th milestone, Mamre (–DA), *Rowe 20* (NBG); Red Hill on Peninsula (–DC), *Taylor 4985* (NBG); Red Hill: Lone Pine, Erica Ridge (–DC), *Taylor 2549*

(BOL, NBG); In sand at Monte Vista (–DC), *Esterhuysen 31301* (BOL); At Bellville (–DC), *Rogers s.n.* (TM 18590); Sandy dunes at Kuilsrivier (–DC), *Zeyher s.n.* (SAM 14016).
–3418 (Simonstown): Sandy flats at abandoned marina between Noordhoek and Kommetjie (–AB), *Esterhuysen 34311* (BOL); Fish Hoek valley (–AB), *Dummer s.n.* (NBG 96445); *Leighton s.n.* (PRE 45991): Sand near Muizenberg beach (–AB), *Schlechter 1255* (GRA); Muizenberg (–AB), *Wolley Dod 1385* (BOL); *Marloth 574* (PRE); Foot of Muizenberg Mountains (–AB), *Macowan 539* (NBG); Witsands (–AB), *Penfold 266* (NBG); Hills behind Steenberg's Cove (–AB), *Leighton 603* (BOL); Schusterskraal (–AB), *Compton 11181* (NBG); Clovelly (–AB), *Compton 13358* (NBG); Near Kommetjie (–AB), *Compton 18930* (NBG); Near Kleinberg, Kommetjie (–AB), *Van Zyl 3969* (NBG); Enclosure at Gifkommetjie turn off, Cape of Good Hope Nature Reserve (–AD), *Taylor 8187* (NBG); Cape Point (–AD), *Rogers C14* (GRA); Rietveld near plot 324, Cape Point (–AD), *Taylor 7138a* (NBG); Vasco da Gama Peak (–AD), *Compton 14598* (NBG); *Leighton 488* (BOL); *Salter 8190* (BOL); *Adamson 2887* (PRE); *Adamson 2889* (BOL); *Phillips s.n.* (SAM 26051); Smitswinkelvlei (–AD), *Steyn 67* (NBG); Western foot of Groot Hangklip Mountain (–BD), *Boucher 762* (NBG).
Unknown or no precise localitiy: Otterdam, Clanwilliam, *Compton 24160* (NBG); In dunes at the Cape, *Zeyher s.n.* (SAM 14497); Between Knersvlakte and Sandveld (Clanwilliam), *Leipoldt 4029* (BOL); Lammkraal, district Clanwilliam, *Schlechter 10832* (BOL, PRE); No locality, *Drege s.n.* (BOL 49228, and PRE 24658); Malmesbbury road, *Penfold s.n.* (NBG 7551); Without locality, *Thunberg s.n.* (UPS).

7.28 Zygophyllum pygmaeum *Eckl. & Zeyh.*: Enumeratio plantarum .....1 : 97 (1835); Sond.: 358 (1860); Huysst.: 70 (1937); Bond & Goldblatt:: 437 (1984). TYPE - Western Cape: In terra limoso-lapidosa (altit. 11) fruticum ad fluvium "Gauritzrivier" (Swellendam). *Eckl. & Zeyh. 769* (S!, lecto, designated here, C!, KIEL, SAM!, TCD!).

Erect, many-stemmed, woody shrub, reaching a height of 0.6 m and a diameter of 1.0 m but usually smaller due to grazing pressure. *Stems*: old stems nude, bark rough, light or dark-gray, cracked; young stems brownish-green, smooth, flat on ventral side, with prominent lateral ridges, sometimes positioned to the center of the flat ventral area, together with several, less prominent, dorsal ridges. *Leaves* opposite, sessile, bifoliolate, regularly spaced or in fascicles on shorter shoots; rachis apex triangular, brownish, reflexed, base thickened, spinescent, 0.5 x 0.5 mm; leaflets articulate, green or glaucous, linear, with an abaxial groove of varying depth and width, leaf margins recurved, often succulent with age dimming out the groove, 7.0–14.0 x 1.5–3.0 mm, apex mucronate in juvenile stage, becoming obtuse with

age, base obtuse; stipules triangular, brown, stiff, reflexed, base thickened, spinescent, one on ventral side, often shallowly notched at apex and one on dorsal side of the stem, 0.5–1.0 x 1.0–1.5 mm. *Flowers* solitary or sometimes 2 together, axillary, usually present in abundance over the length of stems, not only at stem tip. *Pedicel* 8—15 mm long. *Sepals* 5, ovate or obovate, apex rounded, some with membranous margins, 4.0–5.5 x 3.0–3.5 mm. *Petals* 5, widely obovate, 10–12 x 6–8 mm, apex rounded, usually emarginate, base with a short claw, pale or bright yellow, variously marked at base with darker yellow and with red or reddish-brown, M-shaped single figures or tiered or in shapeless blotches. *Nectar disc* fleshy, papillate, regularly 10-angled. *Stamens* 10; filaments terete, 6—7 mm long; staminal scales 10, simple, oblong or narrowly obovate, apex obtuse, upper margins lacerate, 2.0–3.0 x 1.0–1.8 mm, ± 1/3 the length of the filament. *Ovary* spheroid, with sutures visible; style terete; stigma simple. *Fruit* a drooping, subspherical, 5-lobed, loculicidal capsule, base obtuse, apex usually acute, each lobe with a thin, weak, central ridge where splitting will occur, 8–11 x 6–8 mm, always present in abundance. *Seed* oblong, 1 per locule, 3 x 2 mm, dark brown with white aril, testa glossy, smooth, producing, brown, structured mucilage with long spiral inclusions of a uniform width when wet (Figure 7.28.1).

Diagnostic characters and affinities

Z. pygmaeum is recognized by its sessile, bifoliolate leaves with linear leaflets that are variably grooved on abaxial side (Figure 7.28.1.E) and by its 5-lobed capsules, each lobe with a fine, thin central ridge and usually acute apex (Figure 7.28.1.F). It is closely allied to *Z. spinosum* and *Z. rogersii*, which have similar vegetative and floral morphologies. They all have sessile, linear leaflets that are variably grooved on the abaxial side but which differ in dimentions. The leaflets of *Z. rogersii* are the smallest, 5–7 x 1 mm in size, followed by *Z. pygmaeum*, 7–14 x 1.5–3 mm in size, with those of *Z. spinosum* the largest, 10–22 x 2–2.5 mm in size. The 5-lobed fruits of *Z. pygmaeum* usually have an acute apex and are never succulent, whereas those of *Z. spinosum* are succulent when fresh and never with an acute apex. Table 7.8 summarizes the characters of the species in § *Capensia* which have sessile, bifoliolate leaves with terete or linear leaflets.

Figure 7.28.1. *Z. pygmaeum*. A—D, variation in flower markings, A—B, *Van Zyl 4223*; C, *Van Zyl 4216*; D, *Van Zyl 4239*; E, twig with linear, slightly succulent leaflets and a side-view of flower, *Van Zyl 4308*; F, twig with dry, 5-lobed fruits with fine central ridges and an acute apex, *Van Zyl 3647*.

The epithet *pygmaeum* is Latin for dwarf and refers to the size of the twigs representing the type specimen (S and C). The name is probably a misnomer, because *Z. pygmaeum* usually reaches heights of 0.6 m and diameters of 1.0 m, which is not a dwarf size. Ecklon and Zeyher (1835) failed to recognize that their specimen was not a dwarf species, but its small size was the result of grazing.

Distribution and ecology

Z. pygmaeum is widespread in the interior of South Africa (Figure 7.28.2). It occurs from Nieuwoudtville and Calvinia in the north-west, along the Roggeveldberge to the Great and Little Karoo where its eastern boundary is in the Willowmore and Uniondale districts. It occurs in a vegetation classified as **Succulent Karoo Biome**: Upland Succulent Karoo and Little Succulent Karoo (Hoffman 1996) and in **Fynbos Biome**: Escarpment Mountain Renosterveld, Central Mountain Renosterveld and South and South-west Coast Renosterveld (Rebelo 1996). In the Succulent Karoo Biome rainfall occurs during winter and ranges from 150—300 mm per year with hot and dry summers. Substrates are mostly shales from the Bokkeveld Group and Karoo Sequence with conglomerates of the Enon Formation found in the Little Karoo around Barrydale and Oudtshoorn. In the Renosterveld part of the Fynbos Biome, rain occurs mainly during winter months but towards the east, in the Willowmore and Uniondale districts, an increasing summer rainfall component is found. Soils are mostly fertile shale, derived from Karoo Sequence, Bokkeveld, Witteberg and Kango groups. Flowering occurs from June to September. Populations are dispersed over large areas and consist of mature to old individuals with thick, gnarled stems from where repeated resprouting takes place. *Z. pygmaeum* is palatable and popular with grazers (Van Breda & Barnard, no date) and extreme grazing damage occurs. Juveniles and seedlings are rare. Seeds are single in locules and often damaged by insects (Van Breda & Barnard, no date) resulting in a low seed production. This, together with the heavy grazing pressure, could have a negative impact on the future stability of populations. At present this species is still widespread with many populations and seems not to be threatened.
Common name: kleinskilpadbos.

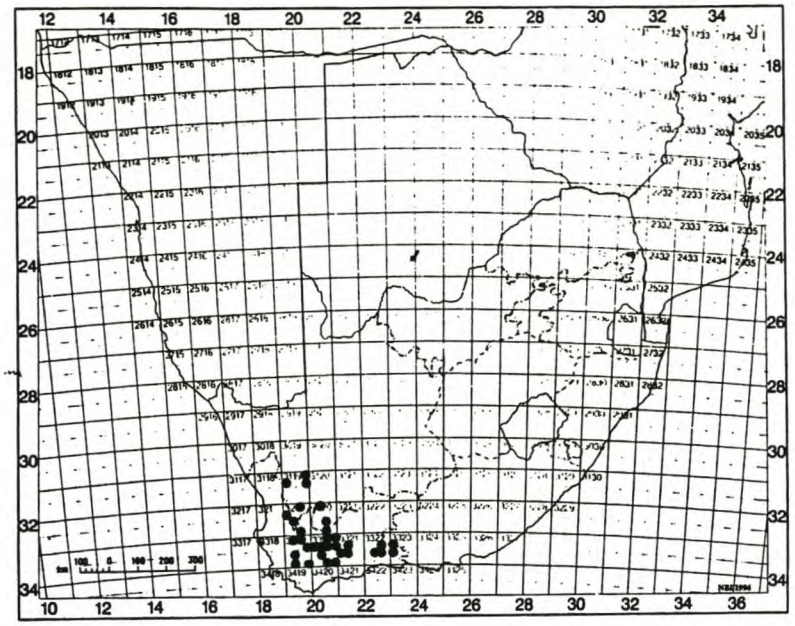


Figure 7.28.2. Geographical distribution of *Z. pygmaeum*.

Specimens examined

–3119 (Calvinia): Dwyka tillite flats in Nieuwoudtville Reserve (–AC), *Perry & Snijman 2165, 2426* (NBG); 12 M SE of Nieuwoudtville on Oorlogskloof road (–AC*), Lewis 2941* (SAM); *Barker 6530* (NBG); Menzieskraal, 40 km from Nieuwoudtville (–BB), *Van Wyk 1476* (NBG); Lower slopes of Hantamberge on Akkerdam (–BD), *Rycroft 2284* (NBG); Shales on Ekerdam Nature Reserve, Calvinia (–BD), *Van Zyl 4030, 4308* (BOL, NBG, PRE).

–3219 (Wuppertal): Ezelbank (–AC), *Schlechter 8835* (PRE); Top of Dassiekloofpas, SW of Calvinia (–BA), *Van Zyl 4216* (NBG); Krommerivier, Clanwilliam (–CB), *Leighton 21581* (BOL); ENE slopes on Kromrivier/Breekkrans boundary (–CB), *Taylor 11427* (NBG); Groenfontein, Swartruggens, Ceres district (–DC), *Van Breda 4562* (PRE).

–3220 (Sutherland): Quaggasfontein, Roggeveld escarpment (–AB), *Rourke 1738* (NBG, PRE); Slopes in Verlatekloof, Sutherland (–DA), *Levyns 1655* (BOL); Flats on De Plaat (–DC), *Fellingham 1224* (NBG).

–3319 (Worcester): Houdenbek, on Bokkeveld slopes, Ceres (–AB), *Adamson s.n.* (BOL 49218); Slopes from Karoo up Swartruggens (–AB/BA), *Levyns 1772* (BOL); S entrance to Karoopoort (–BA), *Van Zyl 4239* (NBG, PRE); *Van Zyl 3744* (NBG); Theronsbergpas, before turn off to Swaarmoed (–BA), *Van Zyl 3934* (BOL, NBG, PRE); 2 km S of Hugo Stasie, NE of De Doorns (–BD), *Van Zyl 3972* (NBG); Roadside near Onse Rus, Brandwacht, Worcester (–CB), *Walters 2456* (NBG); Near McKay's Kop, NE of Viliersdorp (–CD), *Van Zyl 4511* (NBG): Near Avondrust, between Worcester and Villiersdorp (–CD), *Van Zyl 4264* (NBG, PRE); Olifantsdoorn, SE of Robertson (–DD), *Van Zyl 3681, 3682* (NBG, PRE).

–3320 (Montagu): Avondrus, 30 km SE of Touwsrivier (–AC), *Hilton-Taylor 1941* (NBG); Jan de Boers, 10 km E of Touwsrivier (–AC), *Van Breda 4622* (NBG, PRE); De Bron, 15 km WSW of Touwsrivier (–AC), *Glen 1528* (PRE); Witteberg, Laingsburg (–AD/BC), *Compton 5889* (BOL); Witwaterspoort, between Konstabel Stasie and Tweedside Stasie (–AD), *Van Zyl 3947* (NBG, PRE); Ghaapkop, Laingsburg (–BA), *Compton 3048* (BOL); Klein Roggeveld, Laingsburg (–BB), *Compton 7274* (NBG); Bantams Stasie, near Matjiesfontein (–BC), *Van Zyl 3976* (NBG); Near Eselfontein, SE of Laingsburg (–BC), *Van Zyl 3983* (NBG); About halfway between Goedehoop and Vrede, Anysberg Nature Reserve (–BC), *Germishuizen 6692* (PRE); N side of Rooiberg, Ladismith (–BD), *Wurts 1254* (NBG); Suikerdrifkloof (–BD), *Van Zyl 3710, 3712, 3715* (NBG); 25 M NE of Montagu (–CB), *Wisura 2731* (NBG); Jakkalsfontein, Montagu (–CB), *Van Breda 1586* (PRE); Near Barrydale (–DC), *Compton 19579* (NBG); *Morris 206* (NBG); 7.5 M NE of Warmwaterberg Hot Springs (–DD), *Acocks 14561* (PRE); *Van Niekerk 566* (BOL); Lemoenshoek, turn off to Brandrivier (–DD), *Hilton-Taylor 973, 974* (NBG).

–3321 (Ladismith): W side of Bosluiskloofpas (–AD), *Van Zyl 3696* (NBG); 1.9 km from dam in Noukloof Nature Reserve (–CA), *Laidler 27* (NBG, PRE); Near Grootrivier bridge, W of Ladismith (–CA), *Van Zyl 3705* (NBG, PRE); Turn-off to Grootrivier and Kerkplaas, W of Ladismith (–CA), *Van Zyl 3704* (NBG); Algerynskraal, SW of Ladismith (–CA), *Van Zyl 4533* (NBG, PRE); Muiskraal, N of Garcia's Pass (–CA), *Bohnen 8183* (NBG); Naauwkloof Nature Reserve, Ladismith (–CA), *Hilton-Taylor 931* (NBG); Shale flats between Vanwyksdorp and Boerbonefontein (–CB), *Van Zyl 4531* (NBG, PRE).

–3322 (Oudshoorn): Doornkraal, E of De Rust (–BC), *Van Zyl 3642* (BOL, NBG, PRE); *Dâhlstrand 2166, 2303* (PRE); Near Zebra siding, Oudshoorn (–CB), *Taylor 3422* (PRE); Aangenaam, Oudshoorn (–DA), *Van Niekerk 464* (BOL).

–3323 (Willowmore): Nietgenaamd Nature Reserve, near Toorwater (–AC), *Hilton-Taylor 659* (NBG); Zuurbergpoort in Willowmore-Uniondale district (–BC), *Maguire 778* (NBG); Shale flats at Vetvlei, Uniondale (–CA), *Van Zyl 3639* (BOL, NBG, PRE); 3 km W of Uniondale (–CA), *Van Zyl 3628* (BOL, NBG, PRE); 5 km N of Uniondale, on Barandas road to Vetvlei (–CA), *Van Zyl 3638* (NBG, PRE); 14 M from Uniondale (–CA), *Fourcade s.n.* (STE 31760 in NBG).

Unknown or no precise localities: Calvinia, *Schmidt 306* (PRE); Klein Karoo, Oudshoorn, *Taylor 3422* (NBG); Steildrif, Oudshoorn, *Van Niekerk 515* (BOL); Kleinfontein, Oudshoorn, *Thorne s.n.* (SAM 51727); Klein Karoo, near Ecklon & Zeyher's collection site, *Muir 4457* (PRE); *Drege 7172* without locality (S); Gourizrivier, Swellendam, *Ecklon & Zeyher 769* (C, S, SAM,TCD).

7.29 **Zygophyllum rogersii** *Compt.* in Transactions of the Royal Society .....19: 296 (1931); Huysst.: 70 (1937); Bond & Goldblatt: 437 (1984). TYPE - Western Cape: Pieter Meintjes Stasie at 3585 feet, November 1919, *Rogers s.n.* (BOL16311, holo!).

Erect or decumbent, many-stemmed, woody shrub, reaching a height of 0.6 m and a diameter of 1.0 m. *Stems*: old stems nude, resprouting at lower nodes, bark dark gray, flaking; young stems leafy, slender, with a flat ventral area, and with several ridges on remaining part of stem. *Leaves* opposite, sessile, bifoliolate; rachis apex triangular, reflexed, spinescent, 1.5 x 0.5 mm; leaflets articulate, linear, with an abaxial groove of varying depth and width, leaf margins recurved, often becoming succulent with age and groove dimming out, apex mucronate, 5–7 x 1 mm; stipules triangular, reflexed, basis thickened, spinescent, two, widely diverging on ventral side and one on dorsal side of stems, the dorsal stipule sometimes with a shallow, apical notch, 1.0–2.0 x 0.5–0.7 mm. *Flowers* solitary, axillary. *Pedicel* 9—12 mm long. *Sepals* 5, ovate or oblong, apex acute or obtuse, some membranous margined, 5 x 3 mm. *Petals* 5, widely obovate, apex rounded, emarginate, base with a short claw, rose pink, without markings, 9–10 x 5–6 mm. *Nectar disc* fleshy, papillate, 10-angled. *Stamens* 10; filaments terete, 7—8 mm long; staminal scales 10, simple, oblong, upper margins with shallow lacerations, 3 x 1 mm, ± ½ as long as filament. *Ovary* oblong, 5-lobed; style terete, stigma simple. *Fruit* a drooping, loculicidal capsule; when fresh, spheroid and with 5 sutures visible, when dry 5-lobed, each lobe with a fine central ridge where splitting will occur, 9–10 x 8 mm. *Seed* oblong, 1 per locule, 4 x 2 mm, dark brown with white aril, testa smooth and glossy, producing structured mucilage with long spiral inclusions of a uniform width when wet (Figure 7.29.1).

Diagnostic characters and affinities

Z. rogersii is distinguished by its rose coloured petals (Figure 7.29.1), an unique character for the southern African species of *Zygophyllum,* which display only white, yellow or orange petals. *Z. rogersii* is closely allied to *Z. spinosum* and *Z. pygmaeum,* which display similar vegetative and floral morphologies. They all have sessile, bifoliolate leaves with linear leaflets which are variably grooved on the abaxial side. They have similar spinescent, triangular, reflexed stipules which differ in number. On the ventral side of its stems, *Z. rogersii* always displays two stipules that are widely diverging, whereas *Z. spinosum* and *Z. pygmaeum* dispay only one stipule on the ventral sides of their stems. The linear leaflets of *Z. rogersii*

Figure 7.29.1. *Z. rogersii, Van Zyl 3985*. A, leafy twig with rose coloured flowers and immature, spherical fruit; B, back-view of flower; C, well grazed shrub with many short branches resprouting from woody base.

distinguishes it from *Z. teretifolium* and *Z. botulifolium,* both of which have terete and succulent leaflets. The specific epitheton *rogersii* commemorates F.A. Rogers, the collector of the holotype of this species. Table 7.8 summarizes the characters of the species in § *Capensia* with sessile, bifoliolate leaves and terete or linear leaflets.

Distribution and ecology

Z. rogersii is found on the Swartruggens Mountains in the Ceres area and on the Witteberge near Touwsrivier, both mountain ranges forming part of the Cape Fold Belt (Figure 7.29.2). It was almost impossible to classify the localities of this species into the different Biomes as described by Low & Rebelo (1996), but from notes on herbarium specimens and field observations, it is clear that *Z. rogersii* occurs on a substrate derived from sandstone, quartzite and shale or a mixture thereof. The vegetation in which it occurs is described as short Renosterbos or Fynbos with succulent elements occurring at altitudes ranging from 450 m to 1300 m and with rain occurring during winter months. Flowering period is from August to October. Populations are small and localized. Grazing damage to this species is extreme and undamaged plants are rare. Resprouting occurs repeatedly from old, woody branches after heavy grazing (Figure 7.29.1.C).

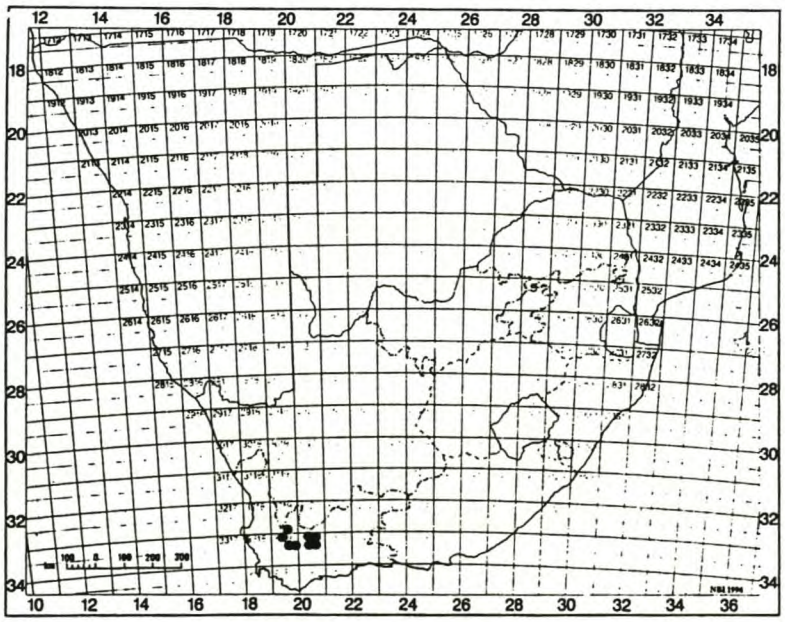


Figure 7.29.2. Geographical distribution of *Z. rogersii.*

Specimens examined

–3219 (Wuppertal): Hartnekskloof, Swartruggens, Ceres-Karoo (–DC), *Van Zyl 4147* (B, BOL, NBG, PRE, S); Near Damskraal turn off, Skitterykloof, Ceres-Karoo (–DC), *Van Zyl 4202* (NBG).
–3319 (Worcester): Uitkyk, Sneeuwkrans, Sutherland (–AB), *Marloth 9861* (PRE); Hottentotskloof, Ceres (–BC), *Compton 16076* (BOL, NBG); Orchard Stasie (–BC), *Rogers 16607* (BOL); Elim, S of Touwsriver, near T-junction with N1 (–BD), *Van Zyl 4243* (NBG).
–3320 (Montagu): Tweedside Stasie, W of Laingsburg (–AB), *Barker 7474* (NBG); Pieter Meintjes Stasie, W of Laingsburg (–AB), *Rogers s.n.* (BOL16311); W of Fisantekraal, S of Matjiesfontein (–AD), *Van Zyl 3985* (GRA,NBG, PRE); Whitehill Stasie, E of Laingsburg (–BA), *Barker s.n.* (BOL 20593); Near Bantams Stasie, on road to SABC- tower (–BC), *Van Zyl 3975* (B, BOL, NBG, PRE, S, WIND); *Compton 12148* (BOL, NBG); Between Fisantekraal and Eselsfontein, SE of Matjiesfontein (–BC), *Van Zyl 3984* (B, BOL, NBG, PRE, S).

Key to the species in § *Capensia* with **sessile leaves and with leaflets not terete or linear but mostly obovate:**

1a Petals white, red-veined, flowers seemingly half-open.....2
1b Petals yellow or yellowish, never red-veined, flowers always wide open.....3

2a Decumbent shrublet with flexible, long, semi-prostrate branches and scabrous-margined leaflets, single stipule with apex usually slightly notched, present on ventral side of stems.....*Z. sessilifolium*
2b Erect, woody shrub or large and sprawling, leaflets sometimes scabrous, always with two stipules present on ventral side of stems....*Z. spitskopense*

3a All parts glabrous.....4
3b Young stems and pedicels densely hirsute..... *Z. hirticaule*

4a Pedicels short, not longer than 2 mm, lateral ridges on ventral side of stem ending in distinct, acute distal lobes.....*Z. fuscatum*
4b Pedicels always longer than 5 mm, lateral ridges not ending in distinct lobes.....5

5a Leaflets small, 5–8 mm long, ...6

5b Leaflets always larger and longer, from 10–25 mm long.....7

6a Young stems rhombic in cross section, one stipule present on ventral side of stems, occurring in Namaqualand.....*Z. namaquanum*

6b Young stems with a flat ventral area and two stipules present on ventral side of stems, occurring in the Eastern Cape.....*Z. divaricatum*

7a Staminal scales with lacerate margins and without a border of papillae.....8

7b Staminal scales with lacerate margins and with a border of papillae.....9

8a Fruits subspheroid, vaguely 5-lobed, slightly wider than long, succulent when fresh, 5-angled and with a wrinkled exocarp when dry .....*Z. flexuosum*

8b Fruit oblong, never succulent, 5-lobed and ridged.....*Z. swartbergense*

9a Leaves prominently cuneate, occurring along the west coast between Hondeklipbaai and Vanrhynsdorp.....*Z. cuneifolium*

9b Leaves obovate, occurring mostly along the south coast.....10

10a Young stems reddish-brown, obviously zigzagging.....*Z. porphyrocaule*

10b Young stems not reddish-brown, straight, ...11

11a Flowers greenish-white or yellowish, posterior petals reflexed, anterior three extended, a single, ventral stipule present.....*Z. calcicola*

11b Flowers yellow, cream-coloured or white, variously marked, all petals with a similar orientation, two ventral stipules present, (if single, then deeply notched) .....*Z. fulvum*

7.30 Zygophyllum divaricatum *Eckl. & Zeyh.* Enumeratio plantarum..... 1 : 97 (1835); Sond.: 360 (1860); Huysst.: 70 (1937). TYPE - Eastern Cape: In collibus calcareis (altit. II) inter flumina "Zondags - et Coegarivier" (Uitenhage), *Ecklon & Zeyher 766* (S!, lecto, designated here, C!, KIEL, SAM!, TCD!).

Erect or spreading, many-stemmed, sparsely to densely leafy shrub, reaching a height of 0.5 m and a diameter of 0.5 m. *Stems*: old stems nude, bark rough, gray, cracked, nodes slightly swollen; young stems smooth, leafy, flat on ventral side and with prominent lateral ridges. *Leaves* opposite, sessile, bifoliolate; rachis apex triangular, brownish, patent, stiff, base thickened and semi-permanent, 1.0 x 0.5 mm; leaflets articulate, green, widely obovate or obovate, apex rounded, usually mucronate, lamina flat, margins smooth and sometimes white-edged, base obliquely obtuse or somewhat cuneate, 5.0–8.0 x 3.5–4.5 mm; stipules triangular, brown, stiff, erect or patent, base semi-permanent, two on ventral side and one on dorsal side of stems, 0.5 x 1.0 mm. *Flowers* solitary, axillary. *Pedicel* 5—10 mm long. *Sepals* 5, ovate or obovate, apex acute or rounded, some with membranous margins, 3.5–4.5 x 2–3 mm. *Petals* 5, obovate, apex obtuse, often emarginate, base with a long claw, yellow, variously marked at base with red or reddish-brown, streaky blotches, 9–14 x 4–8 mm. *Nectar disc* fleshy, papillate, regularly 10-angled. *Stamens* 10; filaments terete, 5.0—6.5 mm long; staminal scales 10, simple, oblong or narrowly obovate, apex obtuse, margins lacerate and bordered on upper, ventral half with dense or sparse papillae of various lengths, 2–3 x 1 mm, ± 1/3 or 1/2 the length of the filament. *Ovary* spheroid, style terete; stigma simple. *Fruit* a drooping, subspheroid, loculicidal capsule, 5-lobed, each lobe with a thin, central ridge, apex acute or obtuse, base obtuse, 8–10 x 6–8 mm. *Seed* oblong, 1–2 per locule, no mature seeds available for study (Figure 7.30.1).

Diagnostic characters and affinities

Z. divaricatum is distinguished by its sessile, bifoliolate leaves with small, obovate, leaflets, 5–8 x 3.5–4.5 mm in size, by its young stems with a flat ventral area and prominent lateral ridges, by two stipules on the ventral side of stems and by its petals with rather long claws. It resembles *Z. namaquanum* which has similar,

Figure 7.30.1. Z. divaricatum, *Ecklon & Zeyher 766*, isolectotype (C).

sessile leaves with even smaller, obovate leaflets, 5–7 x 2–3.5 mm in size. These two species are not closely allied though, because they have different stem and flower morphologies. The staminal scales of *Z. divaricatum* have lacerated margins as well as a border of dense or sparse papillae on its upper ventral surface, whereas those of *Z. namaquanum* have lacerated margins, but lack the border of papillae. The ventral sides of the young stems of *Z. divaricatum* are flat with prominent lateral ridges displaying two stipules at the nodes. The young stems of *Z. namaquanum* are rhombic in cross section displaying only one, sometimes shallowly notched stipules on the ventral side. Their distribution areas are completely allopatric, with *Z. divaricatum* occurring in the Eastern Cape and *Z. namaquanum* in Namaqualand. The epithet probably refers to the branching system of this species. Table 7.9 summarizes the characters of the species in § *Capensia* with sessile, not terete or linear leaflets.

Distribution and ecology

Z. divaricatum has a limited distribution in the Port Elizabeth area (Figure 7.30.2). It occurs in a vegetation classified as **Thicket Biome**: Xeric Succulent Thicket and Mesic Succulent Thicket (Lubke 1996). Rainfall ranges from 300—550 mm per annum and occur during winter or spring-autumn months. Substrates are lime-rich, sandy loam or sandy clays derived from Uitenhage or Ecca Group shales and the vegetation is described as low, sparse thicket with many succulents (Xeric Succulent Thicket) and dense, almost impenetrable, thicket with spinescent shrubs, creepers and succulents (Mesic Succulent Thicket). Summers are hot and usually dry. This species was not seen or collected by me and notes on herbarium sheets are scant. No data on the density of populations or dispersal strategies are available.

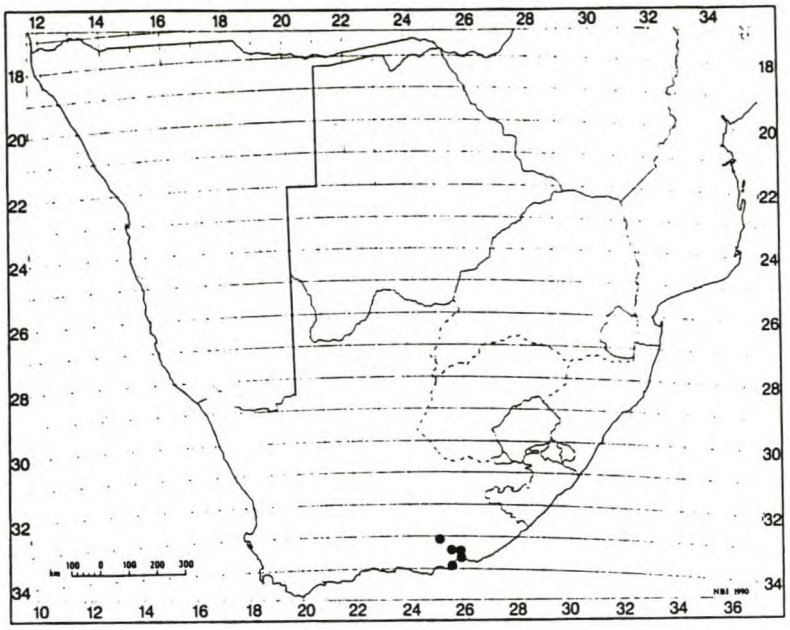


Figure 7.30.2. Geographical distribution of *Z. divaricatum*.

Specimens examined

–3325 (Port Elizabeth): Kommandokraal, between Port Elizabetn and Sondagsrivier (–AA), *Bolus 2665* (BOL, SAM, Z); In Addo Reserve (–BC/BD), *Repton 6043* (PRE); Between Coega and Mackay Bridge (–DA/DC), *Holland 3894* (BOL); Coega, Port Elizabeth (–DC), *Olivier 1652* (PRE); Redhouse near Port Elizabeth (–DC), *Florence Paterson 1182* (BOL, PRE); *I.L. Drège 617* (GRA); *Rogers 3634* (NBG); Sandy, bushveld roadside, Port Elizabeth (–DC), *Bokelmann 2- Plate 39* (NBG).
Unknown or no precise locality: Between Zondags and Coega Rivers, Uitenhage, *Eckl. & Zeyh. 766* (C, S, SAM, TCD); Koegakammakloof ...*Zeyher 2147* (K, SAM).

7.31 Zygophyllum namaquanum *Van Zyl*, sp. nov. (§ *Capensia*), *Z. divaricato* similis foliolis obovatis; sed caulibus juvenibus sectione differentibus: caules *Z. namaquanum* rhombei, stipulo unico latere ventrali; caules *Z. divaricati* area ventrali plana, cristisque lateralibus prominentibus, stipulisque duabus latere ventrali. Squamae staminales *Z. namaquanum* marginibus laceratis sed sine margine papillorum ut in *Z. divaricato*. TYPE - Northern Cape: 10 km N of Steinkopf along N7, *Van Zyl 3824* (NBG, holo, BOL, PRE).

Erect or spreading, many-stemmed, sparsely or densely leafy, woody shrub, reaching a height of 0.6 m and a diameter of 1.0 m. *Stems*: old stems nude, bark rough, dark gray, cracked, twisted, nodes slightly swollen; young stems smooth,

leafy, rhombic in cross section, without ridges. *Leaves* opposite, sessile, bifoliolate; rachis apex triangular, brownish, patent, stiff, base thickened and semi-permanent, spinescent, 1 x 0.8 mm; leaflets articulate, green or glaucous, obovate, apex rounded, usually without a mucro, lamina usually flat but sometimes succulent, margins sometimes scabrous but mostly smooth, base obliquely obtuse or somewhat cuneate, 5.0–7.0 x 2.0–3.5 mm; stipules triangular, brown, stiff, patent or reflexed, base semi-permanent, spinescent, one on ventral side, sometimes with a shallow, apical notch and one on dorsal side of the stem, 0.5 x 1.0 mm. *Flowers* solitary, axillary. *Pedicel* 5—12 mm long. *Sepals* 5, ovate or obovate, apex acute or rounded, some with membranous margins, sometimes glandular on both surfaces, 3.5–6.0 x 3.0–4.0 mm. *Petals* 5, obovate or subrotund, apex obtuse, often emarginate, base with a short claw, yellow, variously marked at base with darker yellow and red or reddish-brown, single or tiered, M- or V-shaped figures and streaky blotches, also visible on reverse side, 8–12 x 5–8 mm. *Nectar disc* fleshy, papillate, regularly 10-angled. *Stamens* 10; filaments terete, 5—6 mm long; staminal scales 10, simple, oblong or narrowly obovate, apex obtuse, margins lacerate, 2.0–2.5 x 1.0–1.5 mm, ± 1/3 the length of the filament. *Ovary* spheroid; style terete; stigma simple. *Fruit* a drooping, subspheroid or ovoid, 5-lobed, loculicidal capsule, each lobe with a thin, central ridge, apex acute, base obtuse, 8–12 x 6–8 mm. *Seed* oblong, 1 per locule, dark brown with a white aril, testa glossy, smooth, producing structured mucilage with long spiral inclusions of a uniform width when wet (Figure 7.31.1).

Diagnostic characters and affinities

Z. namaquanum is distinguished by its sessile, bifoliolate leaves with small (5–7 x 2–3.5 mm in size), obovate leaflets (Figure 7.31.1.A—C), by its young stems that are rhombic in cross section and without lateral ridges, by the single, sometimes shallowly notched stipule on the ventral side of the stems and by its subspheroid or ovoid, 5-lobed fruit with thin, fine ridges and acute apex (Figure 7.31.1.D). *Z. namaquanum* resembles *Z. divaricatum*,which has similar leaves with slightly larger, obovate leaflets, 5–8 x 3.5–4.5 mm in size. However, they are not closely allied, because of morphological differences in their staminal scales and young stems. The

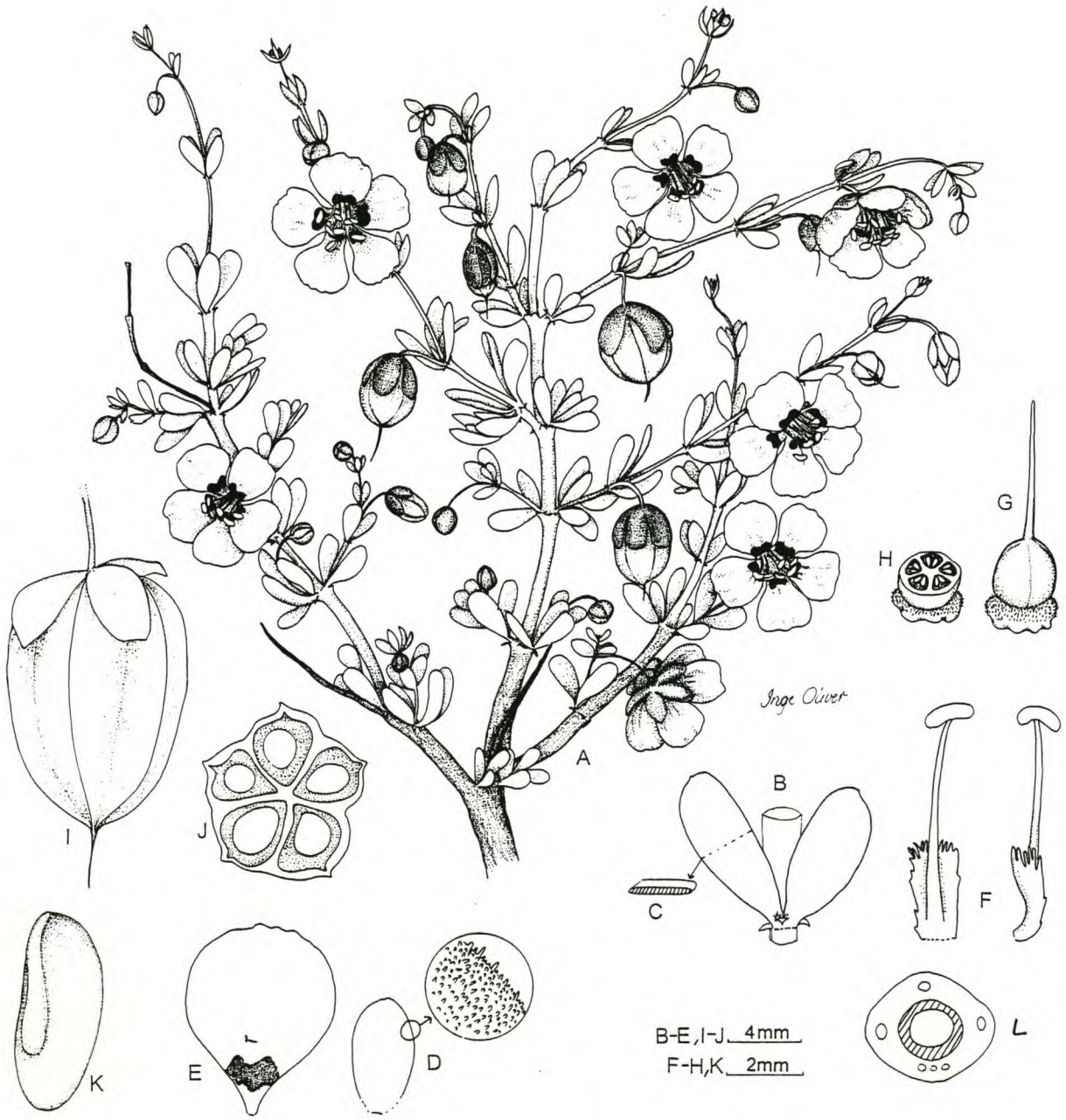


Figure 7.31.1. *Z. namaquanum*, *Van Zyl 4100*. A, flowering and fruiting branch, life-size; B, obovate leaflets; C, cross section of leaflet; D, sepal and enlargement illustrating glandular surface; E, petal; F, dorsal-view and side-view of staminal scale; G, ovary on papillate nectar disc; H, cross section of ovary; I, mature, 5-lobed fruit with acute apex; J, cross section of fruit; K, seed with aril; L, cross section of young stem.

Figure 7.31.2. *Z. namaquanum*, A—C, *Van Zyl 4101*; D, *Van Zyl 3824*. A, twig with yellow flowers and small, obovate leaflets.; B, back-view of flower displaying markings at base of petals; C, habit near Kamieskroon; D, twigs with flowers and many fruits with acute apices.

staminal scales of *Z. divaricatum* have lacerated margins as well as a border of dense or sparse papillae on its upper ventral surface and those of *Z. namaquanum* have lacerated margins lacking the border of papillae. The young stems of *Z. divaricatum* have a flat ventral area and prominent lateral ridges as well as two stipules on its ventral side. The young stems of *Z. namaquanum* are rhombic in cross section and has only one stipule, sometimes shallowly notched at its apex, on the ventral side of the stems. These two species occur in completely separated regions, *Z. divaricatum* in the Eastern Cape and *Z. namaquanum* in Namaqualand. The absence of a papillate border on its staminal scales as well as the presence of a single stipule on the ventral side of the stems of *Z. namaquanum* rather reflect an affinity with *Z. spinosum.* Table 7.9 summarizes the characters of the species in § *Capensia* with sessile, not terete or linear leaves.

Distribution and ecology

Z. namaquanum occurs in Namaqualand, from the Richtersveld in the north to as far south as Leliefontein (Figure 7.31.3). It occurs in a vegetation classified as **Succulent Karoo Biome**: Upland Succulent Karoo (Hoffman 1996) and in **Fynbos**: North-western Mountain Renosterveld (Rebelo 1996). Both these biomes receive rain during winter months, ranging from 150 to 300 mm per annum with hot and dry summers. Soils are rich sandy loam derived from decomposed granite and gneiss. In the Upland Succulent Karoo Biome the vegetation is characterized by dwarf succulent shrubs and in NW Mountain Renosterveld the dominant species is Renosterbos. Populations consist of scattered individuals and are small. This species is palatable because extensive grazing damage occurs which is evident on herbarium specimens and in the field. Undamaged *Z. namaquanum* plants are rare and only found in inaccessible spots. The excessive grazing pressure probably caused a drastic shrinkage of the distribution of this species in the past, probably continuing into the present. Flowering period is from July to September. Fruits are found until November. The epithet refers to its distribution in Namaqualand.

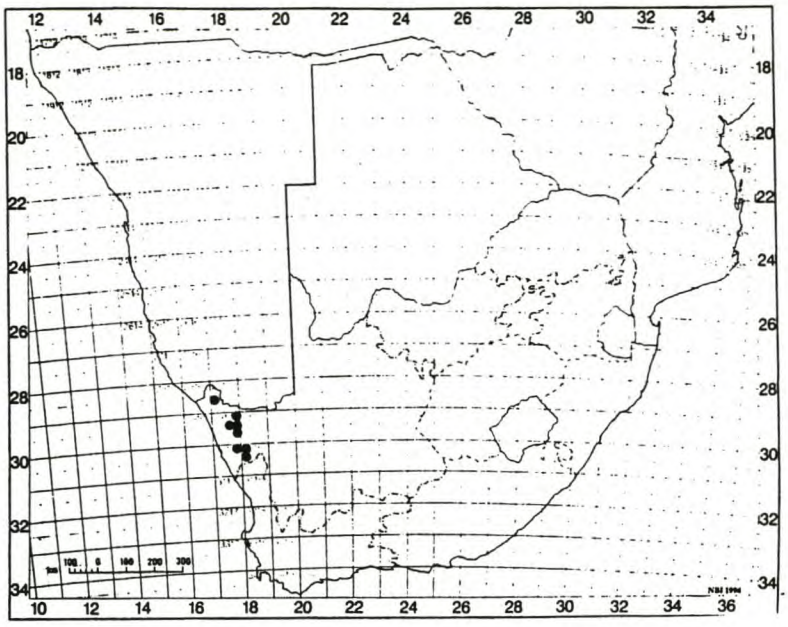


Figure 7.31.3. Geographical distribution of *Z. namaquanum*.

Specimens examined

–2817 (Vioolsdrif): Upper, E slopes of Stinkfonteinsberge, Richtersveld (–CA), *Oliver, Tölken & Venter 589* (PRE); Near Beacon on Cornelsberg (–CA), *Oliver, Tölken & Venter 696* (PRE).
–2917 (Springbok): Along N7, 10 km N of Steinkopf (–BB), *Van Zyl 3824* (BOL, NBG, PRE); Seepage area, ± 8 km from Bulletrap to Nigramoep (–BC), *Van Wyk 6347* (PRE); 4 M W of Springbok (–BD), *Maguire 370* (NBG); O'Okiep Copper Co. golf course at Nabapeep (–DB), *Rösh & Le Roux 20* (WIND); Sandhoogte S of Nabapeep (–DB), *Hugo 3037* (NBG, PRE); Springbok (–DB), *Van der Schijff 8137* (PRE).
–3017 (Hondeklipbaai): Valley near Grootvlei, Kamieskroon (–BB), *Compton 6830* (NBG); *Barker 3742* (NBG); *Acocks 16455* (BOL); Kamieskroonpas, E of Kamieskroon (–BB), *Van Zyl 4099* (BOL, NBG, PRE); Rocky flats near Kamieskroon (–BB), *Bredenkamp 2175* (PRE); Along N7 20 km S of Kamieskroon (–BB), *Van Zyl 4131* (NBG).
–3018 (Kamiesberg): Ou Tuin, E of Kamieskroon (–AA), *Van Zyl 3754, 3931* (BOL, NBG); Between Leliefontein and Garies in the Kamiesberge (–AB*), Esterhuysen 1337* (BOL); Road shoulders in Studor's Pass (–AC), *Van Zyl 3756* (NBG, PRE); Gravel pit along roadside near Leliefontein (–AC), *Le Roux & Ramsey 618* (NBG); Eselfontein, valley S of Leliefontein (–AC), *Van Zyl 4101* (NBG); Sittensberg, SE of Leliefontein (–AC), *Van Zyl 4100* (NBG, PRE).
Unknown or no precise locality: Common on hill above Triangle, *Michell 365* (PRE); Blou Stasie, Namakwaland, *Leighton 1170* (BOL).

7.32 Zygophyllum sessilifolium *L.*. Species plantarum 1 : 385 (1753); Burm.f.: 12 (1768); Lam.: 442 (1786); Ait.: 61 (1789); Thunb.: 80 (1794); Willd.: 563 (1799); Pers.: 463 (1806); Thunb.: 544 (1823); DC.: 706 (1824); Don: 772

(1831); Eckl. & Zeyh.: 96 (1835); Sond.: 358 (1860); Huysst.: 70 (1937); Adamson & Salter: 534 (1950); Kidd: 48 (1950); Bond & Goldblatt: 437 (1984). ICONOTYPE: Burmann, Rariorum africanarum plantarum: 4 t.2, f.1 (1738).

Zygophyllum limosum *Eckl. & Zeyh.*: 96 (1835); Sond. 358 (1860). TYPE - Western Cape: In terris arenoso-limosis fruticum (Altit. II) ad montes prope "Hottentottsholland" (Stellenbosch), *Ecklon & Zeyher 761* (SAM!, lecto, designated here, C!, KIEL, S, TCD!)

Misidentified: *Z. sessilifolium* = *Z. fulvum,* Sims in Curtis's Bot. Mag. 47 t. 2184 (1820).

Decumbent shrublet with long, slender, horizontal stems with erect tips, reaching a height of 0.15 m if standing alone and 0.4 m if supported by other shrubs and a diameter of 2.0 m. *Stems*: old stems horizontal, up to 1.0 m long, pale, thin and flexible, leafless, bark rough, resprouting at nodes; young stems leafy, green, horizontal, 0.3 m long with the last third vertical, flat on ventral side and with lateral ridges. *Leaves* opposite, sessile, bifoliolate, green; rachis apex triangular, reflexed, base semi-permanent; leaflets articulate, flat, obovate, apex rounded or acute, mucronate, margins prominently white-scabrous, base narrowed or cuneate, 11–20 x 3–8 mm; stipules triangular, one on ventral side with apex sometimes notched and one on dorsal side of stems, reflexed, base semi-permanent, 1.5 x 1.5 mm. *Flowers* solitary, axillary. *Pedicel* 15—20 mm, in fruit elongating to 35 mm. *Sepals* 5, ovate or obovate, some with membranous margins, 6.0–10.0 x 3.0–5.5 mm. *Petals* 5, obovate or narrowly obovate, apex obtuse, undulate, praemorse, base with a short claw, posterior two patent during anthesis, white, with red veins not reaching margins, washed at base with browns and yellows, anterior three extended, marked as upper two but usually less prominently so, 8.0–14.0 x 4.0–5.5 mm. *Nectar disc* fleshy, papillate, regularly 10-angled. *Stamens* 10; filaments terete, 5.0—7.5 mm long; staminal scales 10, simple, oblong, apex truncate or obtuse, margins lacerate and bordered with dense or sparse papillae on ventral and sometimes also on dorsal surface, 4.5–5.5 x 1.5–1.8 mm; ± 2/3 the length of the filament. *Ovary* spheroid with 5 sutures visible; style terete; stigma simple. *Fruit* an oblong, loculicidal capsule; when fresh, spheroid or vaguely 5-lobed, when dry distinctly 5-lobed, each lobe with a thin, central ridge where splitting will occur, apex acute, 14–15 x 9 mm. *Seed* oblong, 1 per locule, 4.5–5.5 x 2–2.5 mm, dark brown with a white aril, testa

smooth, glossy, producing yellowish mucilage with long spiral inclusions of a uniform width when wet (Figure 7.32.1).

Diagnostic characters and affinities

Z. sessilifolium is distinguished by its decumbent habit with long, slender, horizontal stems reaching a length of 1.0 m, by its resprouting, short, young branches with erect tips, forming a large, sparse mat (Figure 7.32.1.A), by its seemingly half-open, small, white, red-veined flowers (Figure 7.32.1.B,C), by its staminal scales with lacerate upper margins and bordered by dense papillae, by its filament to scale ratio of 3 : 2 and by its prominently white-scabrous leaf margins (Figure 7.32.1.C). *Z. sessilifolium* is closely allied to *Z. spitskopense* with regard to floral and fruit morphology. Their flowers and fruits are very similar, differing only in size, those of *Z. sessilifolium* always being the largest. They differ markedly in habit, with *Z. sessilifolium* as decumbent shrublet and *Z. spitskopense* as an erect, woody shrub reaching a height of 1.0 m or more. Their leaves differ in some respects. The laminas of *Z. sessilifolium* are flat with prominent scabrous margins whereas the leaf margins of *Z. spitskopense* are recurved and only slightly scabrous. *Z. sessilifolium* has only one stipule on the ventral side of its stems, whereas *Z. spitskopense* always has two. *Z. sessilifolium* has pedicels of 15—20 mm long, elongating in fruit to 35 mm, whereas the pedicels of *Z. spitskopense* are shorter, reaching only 8—12 mm in length. Table 7.9 summarises the characters of the species in § *Capensia* with sessile, not terete or linear leaves.

Geographical distribution and ecology

Z. sessilifolium occurs on the low-lying areas along the West Coast from Darling to Moorreesburg and Stellenbosch, on low koppies usually covered with Renosterveld and in remnants of Renosterveld remaining amongst the wheat fields (Figure 7.32.2). In this area the vegetation is classified as **Fynbos Biome**: West Coast Renosterveld (Rebelo 1996) occurring on shale derived from the Malmesbury group and elements of the Klipheuwel formation. Rainfall varies from 300 to 600 mm per annum and occurs during winter. Summers are hot and dry and conducive to fires.

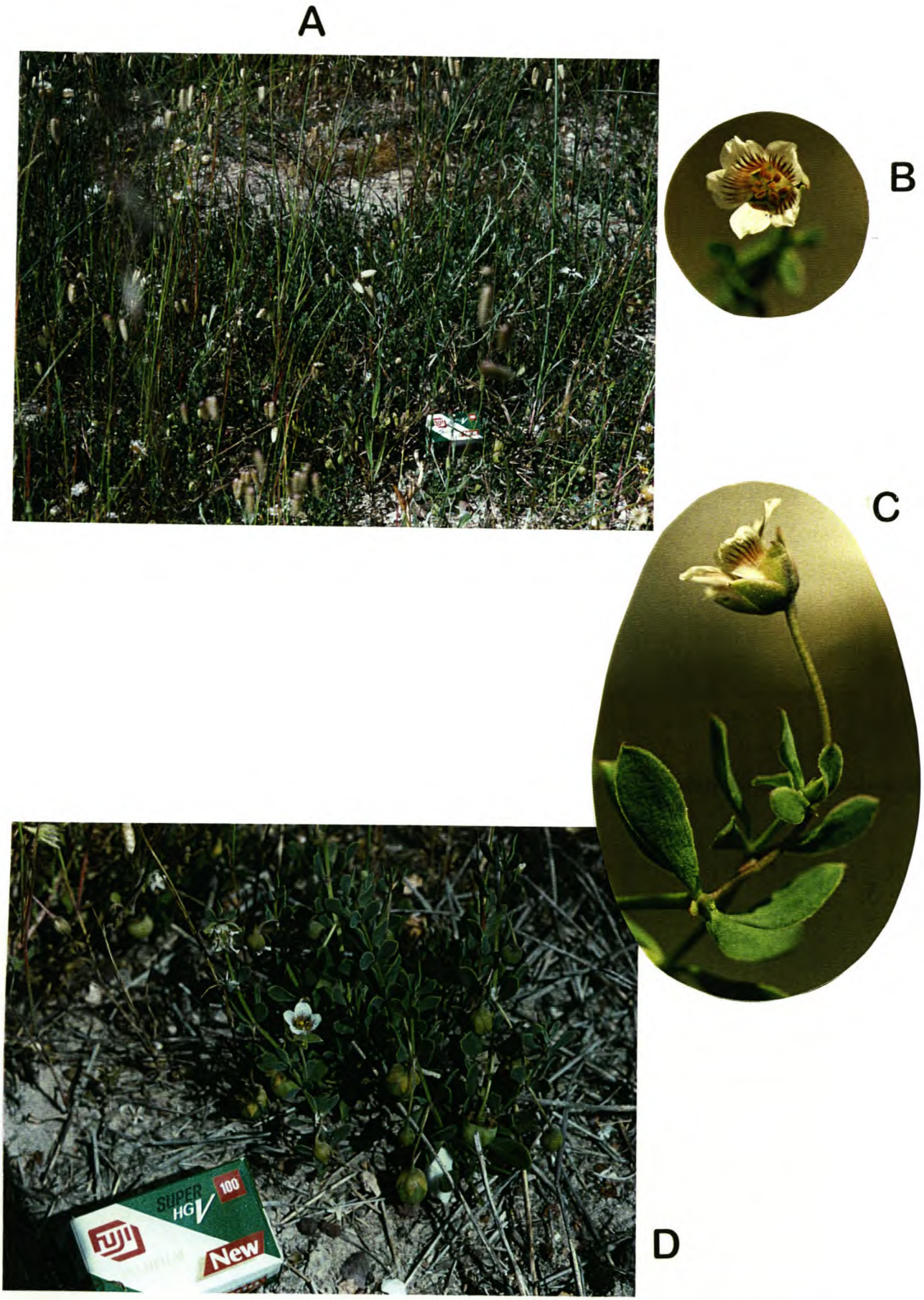


Figure 7.32.1. *Z. sessilifolium, Van Zyl 3685.* A, mat forming habit on Bulelwa, Paarl; B, seemingly half-open flower with red-veined petals; C, twig with prominently scabrous-margined leaves and long-peduncled flower in side-view; D, shrublet with erect flowers and drooping, immature fruits.

Further south in the Peninsula *Z. sessilifolium* is found at higher altitudes, usually on the slopes and on top of the Table Mountain chain on a substrate derived from sandstones, in vegetation classified as Mountain Fynbos (Rebelo 1996). Rain falls in winter and varies from 200 to 2000 mm per annum. A number of collections were also made around the fringes of the Worcester valley on shale, in vegetation classified as Central Mountain Renosterveld (Rebelo 1996). Rainfall for the latter type varies from 250 to 400 mm per annum and falls during winter. Summers for the latter two types are also hot and dry. The flowering period is from July to September. Populations are small, consisting of scattered individuals over small areas. Sometimes it is difficult to distinguish between individuals as *Z. sessilifolium* tend to form extended but sparse mats. Grazing damage does occur. Currently *Z. sessilifolium* is not common in the West Coast Renosterveld, because this habitat is increasingly utilised for wheat production and stock farming. However, this species seems not to be threatened in the Mountain Fynbos habitat.

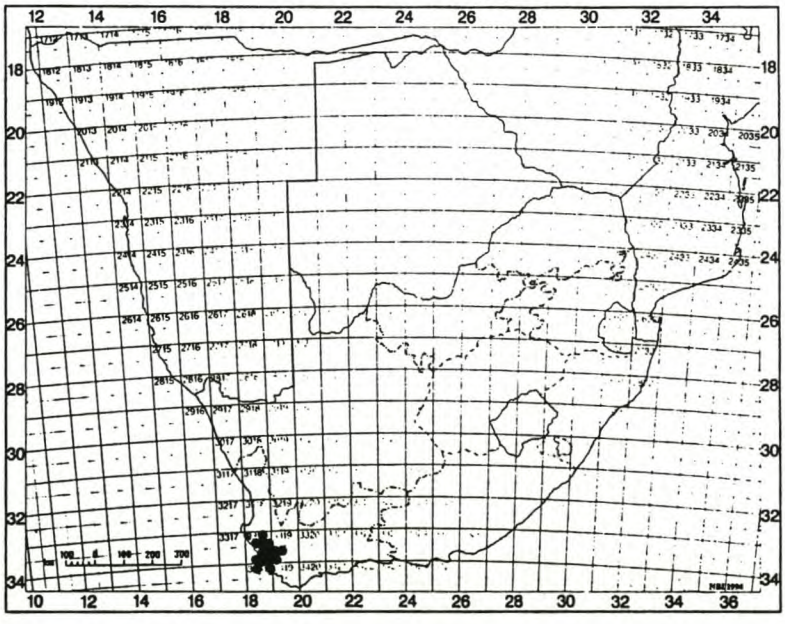


Figure 7.32.2. Geographical distribution of *Z. sessilifolium*.

Specimens studied

–3318 (Cape Town): Darling (–AD), *Compton 19882* (NBG); Darling Flora Reserve (–AD), *Winkler 118* (NBG); Top of Bottelfontein hill, Moorreesburg (–BA), *Van Zyl 3611* (B, BOL, NBG, PRE, S); 5 ml S of Malmesbury (–BC), *Levyns UCT11522* (BOL); Malmesbury (–BC), *Compton 7812* (NBG); Spes

Bona, slopes of Riebeeck-Kasteelberg (–BD*), Van Zyl 4467* (NBG, PRE); Lions Head (–CD), *Anon* (TCD); Cape Town hills (–CD), *Harvey s.n.* (TCD); Slopes of Devils Peak (–CD), *Froembling NBG 96446* (NBG), *Young s.n.* (TM *26425*); Lower, W slopes of Lions Head (–CD), *Lewis 1700* (SAM), *Schlechter 1359* (GRA), *Zeyher s.n. (*SAM 14501); Table Mountain (–CD), *Tyson 2500* (PRE), *Marloth 9368* (PRE), *Ecklon & Zeyher 760* (KIEL, SAM); Above Sea Point Station (–CD), *Wolley Dod 1156* (BOL); Signal Hill (–CD), *Compton 14684* (NBG), *Thode STE 7910* (NBG); Camps Bay (–CD), *Marloth 1551* (PRE); Green Point (–CD), *Zeyher 4701* (BOL); Radiomasts at Klipheuwel (–DA), *Van Zyl 3652* (NBG); At Klipheuwel farm (–DA), *Van Zyl 3651* (NBG); Burgers Post, Pella (–DA), *Boucher & Shepherd 4515* (NBG); Paarl (–DB), *Anon* (TCD); Bulelwa, Agter Paarl (–DB), *Van Zyl 3685* (NBG); Karingmelksvlei, Agter Paarl (–DB), *Van Zyl 3988* (NBG); Wellington (–DB), *Lewis Grant s.n.* (PRE 687637), *Lewis Grant 2231* (BOL, PRE); Areas A & C in Tygerberg Nature Reserve (–DC), *Loubser 3392* (NBG); Upper reaches of Rietvlei, Killarney Race Course (–DC), *Snijman 507* (NBG); Killarney (–DC), *Kroon 10052* (PRE); Langverwacht, above Kuilsriver (–DC), *Oliver 4372* (NBG, PRE); Cape Town to Malmesbury (–DC), *Montgomery 553* (NBG); Brackenfell Nature Reserve (–DC), *Dryfhout 4069* (NBG); Durbanville (–DC), *Compton 13653* (NBG); Koopmanskloof, Stellenbosch (–DD), *Van Zyl 4259* (NBG); Papegaaisberg, Stellenbosch (–DD), *Anon. s.n.* (STE 8803 in NBG).

–3319 (Worcester): 11 M from Worcester towards Bainskloof (–CA), *Story 2912* (PRE); Bainskloof, near Wellington (–CA), *Thompson 18* (PRE); *Kies 112* (NBG); Flats between Olifantsberg and Onderplaas, Worcester (–CB), *Van Zyl 3612* (NBG, PRE); Worcester commonage near aerodrome (–CB), *Van Breda 1731* (NBG); Lower slopes of Perdekop, La Motte State Forest (–CC), *Forsyth 282* (NBG).

–3418 (Cape Town): Llandudno (–AB), *Compton 8948* (NBG); Froggy farm, Simonstown (–AB), *Taylor 6038* (PRE); Golf course at Simonstown (–AB), *Van Zyl 3970* (NBG); Near Houtbaai (–AB), *Bond 136* (NBG); Glencairn mountains (–AB), *Compton 11588* (NBG); Imhoffs Gift, Cape Peninsula (–AB), *Barker 754* (NBG); Bergvliet farm, Constantia (–AB), *Purcell 244* (SAM); Hottentotsholland mountains, Somerset West (–BB), *Ecklon & Zeyher 761* (C, SAM); Somerset West (–BB), *Parker 3718* (NBG); Sir Lowry's Pass (–BB), *Stokoe s.n. (SAM 69017*).

Unknown or no precise locality: Drège s.n. (KIEL).

7.33 Zygophyllum spitskopense *Van Zyl*, sp. nov. (§ *Capensia*). *Z. sessilifolio* L. affinis floribus semiapertis, albis, venis rubris, squamisque staminalibus cum marginibus longe laceratis cum papillis densis vel sparsis marginatis; sed habitu differenti*: Z. spitskopense* frutex erectus vel effusus, ramis lignosis; *Z. sessilifolium* fruticulus decumbens ramis debilibus flexuosis horizontalibus. TYPE - Western Cape: Spitskop, NE of Moorreesburg, *Van Zyl 4127* (NBG, holo., BOL, PRE, S).

Erect or sprawling, woody shrub reaching a height of 1.2 m and a diameter of 1.0 m. *Stems*: old stems nude, often resprouting, bark grey; young stems green, smooth,

flat on ventral side and with lateral ridges. *Leaves* opposite, bifoliolate, sessile; rachis apex triangular, reflexed; leaflets articulate, glaucous or green, cuneate or narrowly obovate, apex rounded, mucronate, margins recurved, sometimes scabrous, base cuneate,12–16 x 2–4 mm; stipules triangular, reflexed, two on ventral side and one on dorsal side of the stem, the dorsal stipule is sometimes notched, 2 x 1 mm. *Flowers* solitary, axillary. *Pedicel* 8—12 mm long. *Sepals* 5, ovate or elliptic, some membranous margined, 4.5–8 x 3–4.5 mm. *Petals* 5, sometimes convex, narrowly obovate, 8–9 x 3–5 mm, apex rounded, often undulate, base with a long claw, posterior two patent, white, variously marked with short, red veins or without red veins, washed at base with brownish-red or dirty yellow, anterior three extended, marked as posterior two but usually less prominently so. *Nectar disc* fleshy, papillate, regularly 10-angled. *Stamens* 10; filaments terete, 5—6 mm long; staminal scales 10, simple, narrowly oblong, apex rounded or acute, margins lacerate and bordered with dense or sparse papillae on ventral and usually also on dorsal surface, 4.0–4.5 x 1.0–1.5 mm; ± 2/3 the length of the filament. *Ovary* spheroid, with 5 sutures visible; style terete; stigma simple. *Fruit* a drooping, spheroid or oblong, loculicidal capsule; when fresh spherical, vaguely 5-lobed; when dry distinctly 5-lobed, each lobe with a central ridge where splitting will occur, apex truncate, 9–12 x 7–9 mm. *Seed* oblong, 1 per locule, 4 x 2 mm, dark brown with a white aril, testa smooth and glossy, producing structured mucilage with long spiral inclusions of a uniform width when wet (Figure 7.33.1).

Diagnostic characters and affinities

Z. spitskopense is distinguished by its small, seemingly half-open white, red-veined, red-blotched flowers (Figure 7.33.2.A—C), by its staminal scales with lacerated margins and a border of dense or sparse papillae and by its filament to scale ratio of 3 : 2. *Z. spitskopense* is allied to *Z. sessilifolium* which have similar small, red-veined, white flowers differing only in dimensions, those of *Z. sessilifolium* the largest. They also have similar, 5-lobed, 5-ridged fruits, those of *Z. sessilifolium* with acute apices whereas those of *Z. spitskopense* tend to have truncate apices. They differ in the number of stipules on the ventral side of their stems, *Z. spitskopense* has two stipules and *Z. sessilifolium* only one. Although *Z. leptopetalum* also have

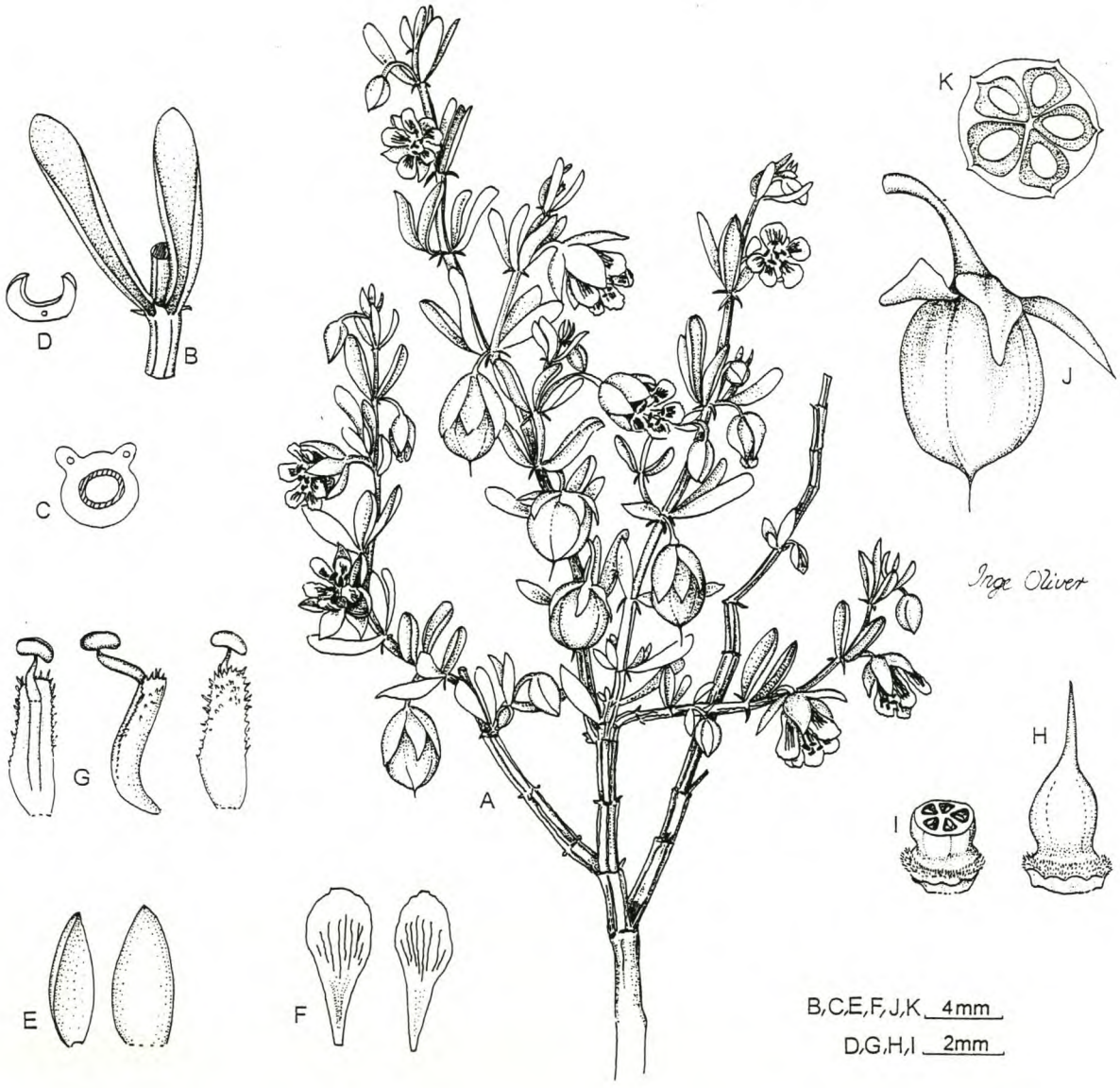


Figure 7.33.1. Z. spitskopense, *Van Zyl 4127*. A, flowering and fruiting branch, life-size; B, obovate leaflets with recurved margins; C, cross section of young stem; D, cross section of leaflet; E, sepals; F, petals; G, dorsal-, side-, ventral-view of staminal scale; H, ovary on papillate nectar disc; I, cross section of ovary; J, immature, vaguely 5-lobed fruit; K, cross section of immature fruit.

Figure 7.33.2. *Z. spitskopense*. A, *Van Zyl 4256*; B—E, *Van Zyl 4510*. A—C, small, red-veined, white flowers from various angles; D, old stems repeatedly resprouting after heavy grazing; E, sprawling habit in the Worcester area.

white flowers with red veins which resemble those of *Z. sessilifolium* and *Z. spitskopense,* it differs from them in having petiolate leaves whereas *Z. spitskopense* and *Z. sessilifolium* both have sessile leaves. *Z. leptopetalum* has a filament/scale ratio of 5 : 4 while that of the other two species are 3 : 2. With the exception of one rose pink-flowered species, *Z. rogersii* and the white flowered species mentioned above, most species in § *Capensia* have large, yellow flowers that open widely during anthesis. The specific epithet refers to the type locality. Table 7.9 summarises the characters of the species in § *Capensia* with sessile, not terete of linear leaves.

Distribution and ecology

Z. spitskopense occurs on the lower slopes of the Piketberg and Olifantsrivier Mountains, on the west coast lowlands and in the Worcester valley (Figure 7.33.3). It is found in a vegetation classified as **Fynbos Biome**: Mountain Fynbos, West Coast Renosterveld and Central Mountain Renosterveld (Rebelo 1996). On the Olifantsrivier Mountains it occurs in sandy soils derived from sandstones in vegetation classified as Mountain Fynbos. On the west coast lowlands from Hopefield towards Moorreesburg it occurs in the remaining areas of veld in the wheat fields on a substrate of shale derived from the Malmesbury group and elements of Klipheuwel formation in a vegetation classified as West Coast Renosterveld. To the east, in the Worcester valley, populations occur on sandy valley floors in vegetation classified as Central Mountain Renosterveld. Individuals from this area have a compact, sprawling habit, are densely leafy and are inclined to succulency (Figure 7.33.2.E), probably in reaction to the different climatic conditions. Flowering and fruiting occur from July to September. *Z. spitskopense* is never common. Populations consist of few individuals which are often excessively grazed. Fruit production is low due to grazing pressure and loculi are always 1-seeded. However, its ability to resprout repeatedly from old wood (Figure 7.33.2.D) probably enables this species to overcome grazing pressures, which is a real hazard. Grazing pressure, together with the increasing agricultural development of its habitat, are real threats to this species.

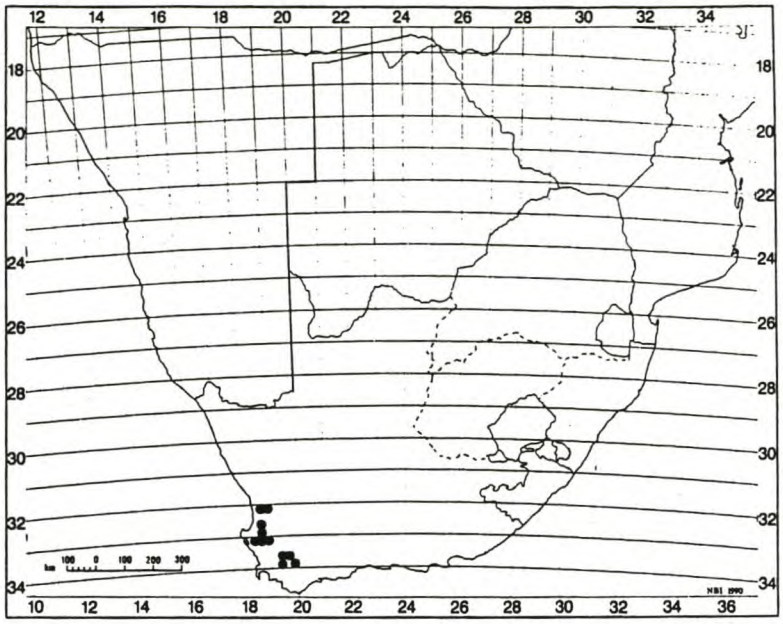


Figure 7.33.3. Geographical distribution of *Z. spitskopense*.

Specimens examined

–3218 (Clanwilliam): Between Clanwilliam and Graafwater (–BA/BB), *L. Bolus 23173* (BOL, K);Koppie near Het Kruis (–DA), *Compton 10544* (NBG); Near The Castle, De Hoek, Piketberg (–DC), *Van Zyl 3610* (BOL, NBG, PRE); De Hoek, Piketberg (–DC), *Barker 5820* (NBG), *Bond 1031* (NBG), *Maguire 2036* (NBG); Piketberg (–DC), *Compton 6888* (NBG).

–3318 (Cape Town): Enkelvlei, Hopefield (–AB), *Van Zyl 4466* (NBG); Swartberg farm, Moorreesburg (–BA), *Van Zyl 4256* (B, NBG, PRE, S); Spitskop farm, NE of Moorreesburg (–BB), *Van Zyl 4127* (BOL, NBG, PRE, S); S, lower slopes of Heuningberg, Twenty-Four Rivers area (–BB), *Boucher 3900* (NBG); Groot Sandfontein, Moorreesburg (–BB), *Jordaan 605* (NBG).

–3319 (Worcester): East Zweletemba, Worcester (–CB), *Bayer 3217* (NBG); Reiersrus, Aan De Doorns, Worcester (–CB), *Walters 2574* (NBG); Draaivlei, Doringrivier, Worcester (–CD), *Walters 1843* (NBG); Villiera, gravel road between Worcester and Villiersdorp (–CD), *Van Zyl 3655* (BOL, NBG, PRE), *Van Zyl 4266* (BOL, NBG, PRE); Lower slopes of Langeberge, Amandalia, Robertson (–DA), *Van Zyl 3987* (NBG); Between Silveroaks and Erfdeel, S of Robertson (–DD), *Van Zyl 3677* (BOL, NBG, PRE).

7.34 Zygophyllum cuneifolium *Eckl. & Zeyh.* Enumeratio plantarum..... 1 : 97 (1835); Sond.: 359 (1860). TYPE - Western Cape: In lapidosis (altit. II) ad montes prope ostium fluvii "Orangerivier" (Namaqualand), *Ecklon & Zeyher 767* (S!, lecto, designated here, P!). The type locality given by Ecklon & Zeyher as the mouth of the Orange River in Namaqualand is probably incorrect and should be Olifants River

mouth. *Z. cuneifolium* is not found close to the Orange River and the closest locality to the Orange River is at Hondeklipbaai.

Zygophyllum crassifolium Huysst.: 70 (1937). TYPE - Western Cape: Karee Bergen, 500 m, Zwischen Vanrhynsdorp und Garies, *Schlechter 8309* (SAM!, lecto, designated here, PRE!, Z!)

Zygophyllum rigescens E.Mey.: 96 (1843) nom. nud. Mierenkasteel, karrooagtige Hohe, unter 1000 Fuss, August, Drège s.n. (S!).

Spreading or erect, many-stemmed shrub reaching a height of 0.6 m and a diameter of 0.8 m. *Stems*: old stems leafless, bark dark grey; young branches reddish-green, smooth, flat on ventral side and with two lateral ridges, nodes prominently swollen. *Leaves* opposite, bifoliolate, sessile; rachis apex triangular, reflexed, 1.5 x 1.5 mm; leaflets articulate, cuneate, succulent, flat, midrib visible when dry, glaucous or green, apex obtuse, not mucronate, base cuneate, 12–23 (30) x 3.5–4 (7) mm; stipules widely triangular, one on ventral side and one on dorsal side of stem, 1.5 x 1.5 mm. *Flowers* solitary or seldomly two together, axillary. *Pedicel* 12—14 mm long, elongated and recurved in fruiting stage so that fruits are hidden amongst the leaves. *Sepals* 5, ovate or obovate, some membranous margined, sparsely covered with short hairs or glabrous, 5 x 2 mm. *Petals* 5, elliptic or ovate, 12–15 x 5–7 mm, apex obtuse or acute, base with a short claw, lime yellow, variously marked at base with vaguely V-shaped, blotches topped with broad serrated bands in browns, khaki, darker yellow or reddish-brown or without any markings. *Nectar disc* fleshy, papillate, regularly 10-angled. *Stamens* 10; filaments terete, 7—8 mm long; staminal scales 10, simple, oblong or obovate, upper margins with long lacerations and upper half of ventral and dorsal surface papillate, 3–4 x 1 mm; ± ½ the length of the filament. *Ovary* ovoid, 5-lobed; style terete; stigma simple. *Fruit* a droopy, ovoid, 5-lobed, loculicidal capsule, each lobe with a prominent ridge, apex acute, 10–14 x 8–12 mm. *Seed* oblong, 1 or 2 per locule, 6–7 x 3 mm, dark brown with a white aril, testa smooth and glossy, producing structured mucilage with long, spiral inclusions of a uniform width when wet (Figure 7.34.1).

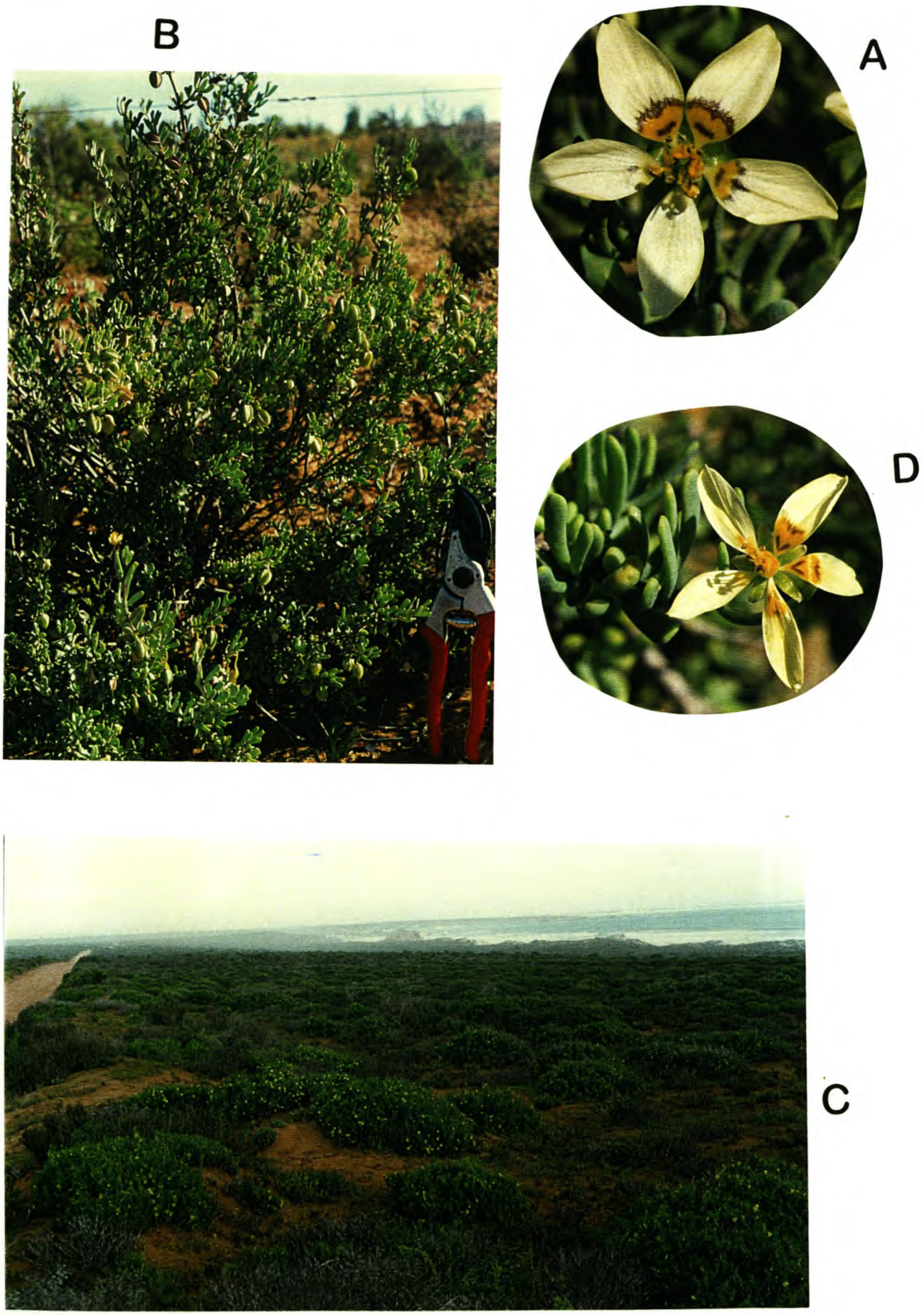


Figure 7.34.1. *Z. cuneifolium*. A–B, *Van Zyl 3991*; C–D, *Van Zyl 3949*. A and D, open flowers illustrating the variation in flower markings; B, erect shrub with many ridged fruits; C, habit and dominance in communities at Doringbaai.

Diagnostic characters and affinities

Z. cuneifolium is recognized by its cuneate leaflets (hence the specific epithet), 12–23 x 3.5–4.0 mm in size, by the lacerated upper margins and the papillae on the ventral and dorsal surfaces of the staminal scales, by the 5-lobed fruits with prominent ridges where splitting will occur. *Z. cuneifolium* is related to *Z. teretifolium*. They both have similar swollen nodes and rather large seeds, those of *Z. cuneifolium* 6–7 x 3 mm and those of *Z. teretifolium* 5–6 x 2–3 mm in size as well as a similar filiment to scale ratio of 2 : 1 each. They differ with regard to leaf morphology, *Z. teretifolium* with terete, succulent leaflets and *Z. cuneifolium* with cuneate leaflets. Table 7.9 summarizes the characters of the species in § *Capensia* with sessile, not terete or linear leaves.

Distribution and ecology

Z. cuneifolium is found on the low-lying parts of the west coast, from Hondeklipbaai in the north to as far south as Vanrhynsdorp in the south (Figure 7.34.2). It occurs in a vegetation classified as **Succulent Karoo Biome** (Hoffman 1996): Strandveld Succulent Karoo, consisting of low shrubs, annuals and geophytes on a substrate of calcareous sands in a narrow strip close to the coastline; and Lowland Succulent Karoo further inland, dominated by dwarf succulents, mainly members of the Mesembryanthemaceae. The Lowland Succulent Karoo occurs on richer soils derived from granite and gneiss. Rainfall for both vegetation types occur during winter months and is generally quite low, ranging from 50 to 300 mm per annum. Summers are hot and dry. Large populations of many scattered individuals occurs. Grazing damage does occur. Along the coast, in Strandveld Succulent Karoo, *Z. cuneifolium* often takes a dominant position in plant communities (Figure 7.34.1.C). During late autumn, after the first winter rains, flowers and fruits are borne on shoots of the previous spring. At the same time many germinating seeds and seedlings are seen usually in close proximity to mother plants. Mid winter cold brings a pause in growth activities, but vegetative growth proceeds again during spring and early summer with vigorous, new growth visible on all plants, but without any flowers. Flowers close at night and during misty or cloudy weather. Ageing of shrubs causes

a marked decrease in leaf size as well as bronzing of the leaves. Seasonal changes in the general appearance of the plants are pronounced and they vary from a lush, green, densely leafy state in the winter to spring period, to a bronzed, dry, less leafy but never quite leafless state during the arid, hot summer months.

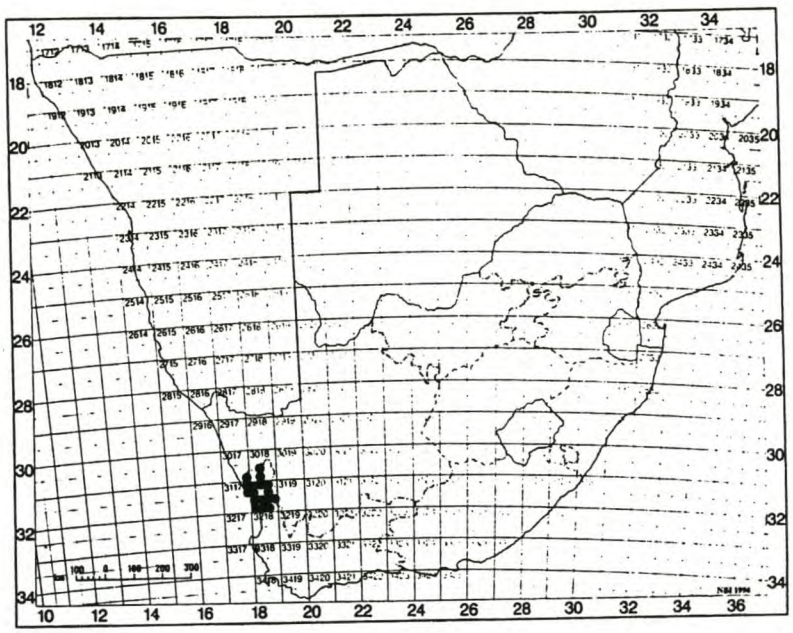


Figure 7.34.2. Geographical distribution of *Z. cuneifolium*.

Specimens examined

–3017 (Hondeklipbaai): Ou Dam, 12.5 km NE of Kotzerus (–DD), *Hilton-Taylor 1425* (NBG).

–3018 (Kamiesberg): Past Uitspanberg, N of Bitterfontein (–CB), *Van Zyl 3751* (NBG); Gravel road to Kwanous, N of Bitterfontein (–CD), *Van Zyl 3748* (NBG).

–3117 (Lepelfontein): 42 km N of Landplaas (–BB), *Van Zyl 4370* (NBG, PRE); Brand se Baai, NE of Nuwerus (–BD), *Van Zyl 4011* (BOL, NBG); *Van Breda 4523* (PRE).

–3118 (Vanrhynsdorp): Mierhoofd Kasteel, Vanrhynsdorp (–AA), *Barker 6205* (NBG); Hendriksvlei, NE of Nuwerus (–AA), *Van Zyl 4009* (B, NBG, WIND); Kareebergen (–AB), *Schlechter 1033* (PRE, SAM); *Schlechter 8309* (Z); NW side of Kareeberge, Nuwerus (–AB), *Van Zyl 4004* (B, BOL, NBG, PRE, S, WIND); Kwaggaskop, N of Vanrhynsdorp (–AB), *Van Zyl 3953* (NBG); 2 km N of Landplaas turn off (–AC), *Van Zyl 4366* (NBG, PRE); 1 km from Kliprand turn off from N7 (–BA), *Van Zyl 4001* (NBG, PRE); 30 km N of Vanrhynsdorp next to bridge on N7 (–BC), *Van Zyl 4000* (NBG); Rocky hills at Oranjerivier mouth (--CA), *Ecklon & Zeyher 767* (S); Papendorp, at Olifantsrivier mouth (–CA), *Van Zyl 3993* (NBG); N side of Olifantsrivier, near Kliphuis, Koekenaap (–CA), *Van Zyl 4014* (NBG, PRE); Liebendal, 7 m N of Vredendal (–CB), *Hall 3638* (NBG, S); Holrivier (–CB), *Van Zyl 3600, 3657, 3657a* (NBG); Bakleiplaas, NW of Vredendal (–CB), *Van Zyl 4146* (NBG, PRE); N side of Doornbaai (–CC), *Acocks 23990* (PRE); *Boucher 117* (NBG); Bobbejaansklip, S of Doornbaai (–CD), *Van Zyl*

CD), *Van Zyl 4111* (NBG, PRE); Lamberts Bay - Clanwilliam road, at turn off to Doornbaai (–CD), *Van Zyl 3989* (B, BOL, NBG, PRE, S, WIND); Turn off to Knakkiesberg, between Klawer and Vredendal (–DA), *Van Zyl 3658* (NBG, PRE); Rocky hills just W of Vanrhynsdorp (–DA), *Van Zyl 4109, Van Zyl 3959* (NBG, PRE); N of Vanrhynsdorp (–DA), *Van Zyl 3949* (NBG); Urionskraal, Vanrhynsdorp (–DB), *Van Zyl 3958a* (NBG); 1 km N of Klawer, going to Vredendal (–DC), *Van Zyl 4245* (NBG); Between Kleinberg and Remhoogte, SE of Vredendal (–DC), *Van Zyl 4255* (NBG, PRE); 29 km N of Clanwilliam, between Rooioond and Sandkraal (–DC), *Van Zyl 4305a* (NBG).

7.35 Zygophyllum hirticaule *Van Zyl* in Van Zyl & Marais, Bothalia 29,2 : 235 (1999). TYPE - Namibia: Nord Witputz 22, 55 km N of Rosh Pinah, *Van Zyl 3894* (NBG, holo, B, PRE, S, WIND).

Decumbent, compact shrublet, reaching a height of 0.3 m and a diameter of 0.5 m. *Stems*: old stems glabrous with swollen nodes and ivory coloured bark; young stems hirsute, round in cross section or slightly flat on ventral side but without lateral ridges. *Leaves* opposite, sessile, bifoliolate; rachis apex triangular, reflexed, 2.5 x 1 mm; leaflets articulate, asymmetrical, glaucous, leathery when fresh, warty when dry because of numerous, embedded crystals, glabrous or glabrescent on margins and at base, obovate, 20–40 (47) x 13–25 (34) mm, apex rounded, base cuneate; stipules fleshy, widely triangular or subrotund, margins fringed, tomentous on dorsal side, caducous, one on ventral and one on dorsal side of stems, 2–3 x 3–6 mm. *Flowers* solitary or two together, axillary. *Pedicel* densely hirsute, up to 20 mm long. *Sepals* 5, ovate, tomentous on dorsal side, green when fresh, persistent, becoming brown or burgundy-coloured in fruit, 8 x 4–5 mm. *Petals* 5, elliptic or obovate, 10–13 x 5–8 mm, apex obtuse or acute, emarginate, undulate, base with a short claw, bright yellow, not marked at base. *Nectar disc* fleshy, papillate, regularly 10-angled. *Stamens* 10; filaments terete, 7—8 mm long; staminal scales 10, simple, oblong, apex truncate or rounded, margins with long lacerations and upper half of both surfaces densely papillate with papillae of various lengths, 3.5–4.0 x 1.5 mm, ± ½ the length of the filament. *Ovary* oblong, 5-angled, tomentous, with 5 glabrous, rudimentary wings, apex retuse; style terete, stigma simple. *Fruit* an oblong, drooping, burgundy-coloured, 5-winged, loculicidal capsule with tomentous sides and glabrescent wings, wings ca. 2 mm wide, 13–17 x 11–13 mm. *Seed* oblong, 1—3 per locule, 4 x 2 mm, dark brown with a white aril, testa smooth, glossy, producing

structured mucilage with long, spiral inclusions of a uniform width when wet (Figure 7.35.1).

Diagnostic characters and affinities

Z. hirticaule is distinguished by its hirsute young stems (hence the epithet), pedicels and sepals (Figure 7.35.2.A—B), by its large, 20–40 (47) x 13–25 (34) mm in size, glaucose, obovate leaflets (Figure 7.35.2.A) and by its burgundy-coloured, tomentose fruits with narrow, ± 2mm wide, glabrescent wings. Although *Z. debile* have similar, but glabrous fruits, these two species are not closely related and belong to different groupings within § *Capensia*. *Z. hirticaule* with its sessile leaflets belongs to the group with sessile, not terete or linear leaves, and *Z. debile* belongs to the group with petiolate leaves. The hairy stems of *Z. hirticaule* resemble those of *Z. leptopetalum*, *Z. pubescens* and *Z. maculatum,* but those of the latter three are striate as well, differing from those of *Z. hirticaule* which lack striae. With regard to floral morphology, *Z. hirticaule* displays similar staminal scales and filament to nectar scale ratios as is found in the group of species in § *Capensia* with sessile, not linear or terete leaves, but remain somewhat isolated with regard to its leaf morphology and indumentum. Table 7.9 summarizes the characters of the species in § *Capensia* with sessile, not terete or linear leaflets.

Distribution and habitat

Z. hirticaule is found in the south of Namibia in the Rosh Pinah area (Figure 7.35.3). It occurs in a vegetation classified as **Succulent Karoo Biome** (Irish 1994), which is characterized by chamaephytic dominance. Summers are hot and dry with frequent periods of drought. Rainfall is low and occurs during winter. Populations are large, including many seedlings and juveniles, growing on sparsely vegetated, rocky, desert flats on a substrate of mixed dolomite and dolorite. *Z. hirticaule* is drought deciduous in response to water stress, like several other *Zygophyllum* species. In the leafless state these shrubs with their remaining ivory-coloured stems are prominent in the landscape (Figure 7.35.2.D), but stems resprout and return to a leafy state soon after rains (Figure 7.35.2.C). Since grazing damage appears

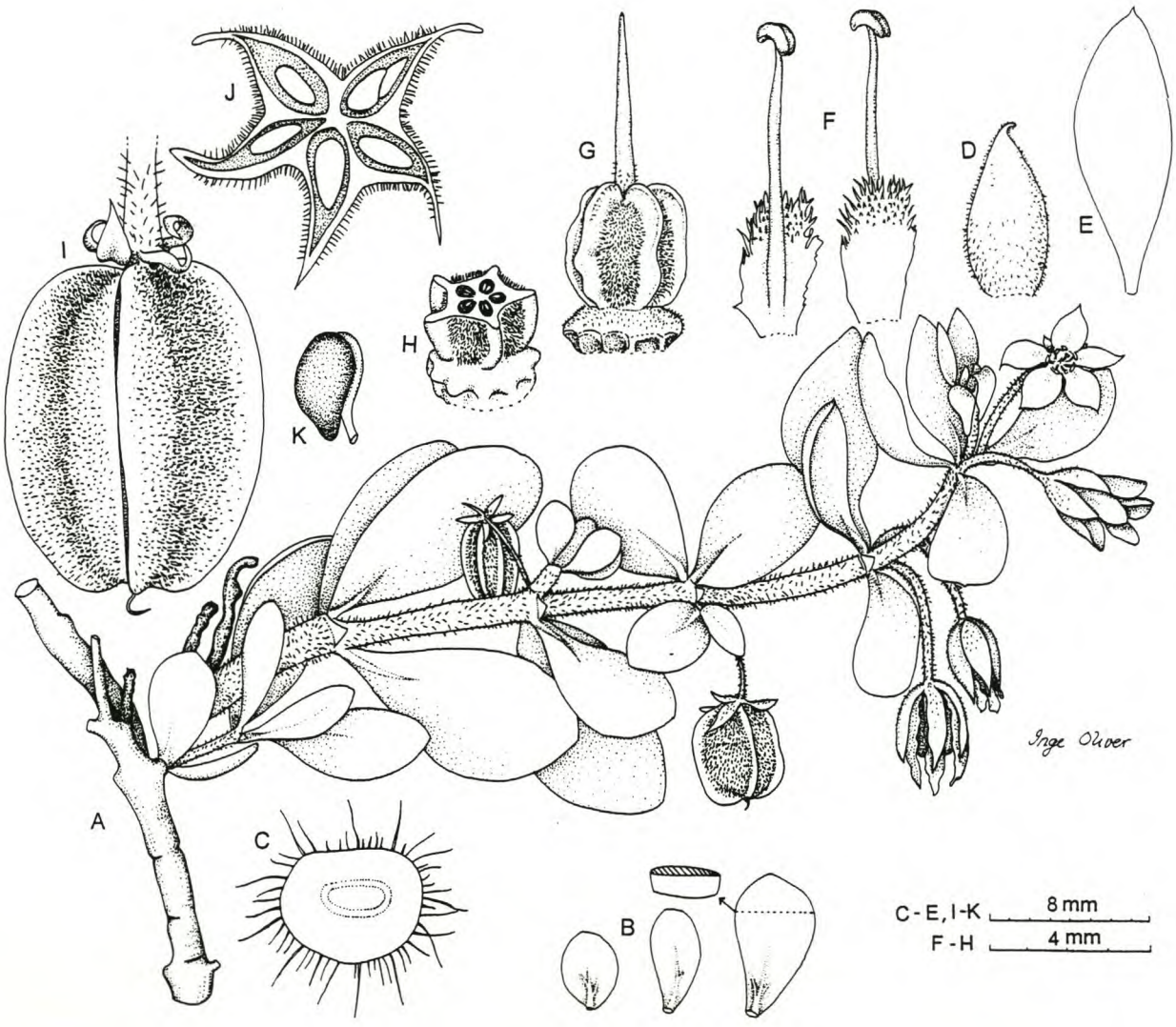


Figure 7.35.1. *Z. hirticaule*. A—H, *Van Zyl 4480*, I—J, *Van Zyl 3902*. A, flowering and fruiting branch, life-size; B, range of leaves plus a cross section, half-size; C, cross section of young stem; D, sepal; E, petal; F, dorsal- and ventral-view of staminal scale; G, ovary on papillate nectar disc; H, cross section of ovary; I, mature, dry fruit; J, cross section of dry fruit; K, seed with aril.

A

B

C

D

Figure 7.35.2. *Z. hirticaule, Van Zyl 3902*. A, twig with large, glaucous leaves, hirsute young stem and pedicel and flower; B, yellow, unmarked flower with hairy sepals clearly visible; C, habitat at Witputz, depicting a leafy state during August; D, the same locality, depicting a leafless state during December.

minimal and as farming activities have a low profile in this area, this species seems not threatened at present. Flowering period is from May to August and shedding of the fruit occurs soon afterwards.

A specimen, resembling this species, but totally glabrous, was collected at Delphin kopf, Spencer Bay, (*Giess & Robinson 13206*, WIND). This locality falls within a restricted mining area and in sandy desert terrain. For a final opinion on this specimen, better field observation and more collections are necessary.

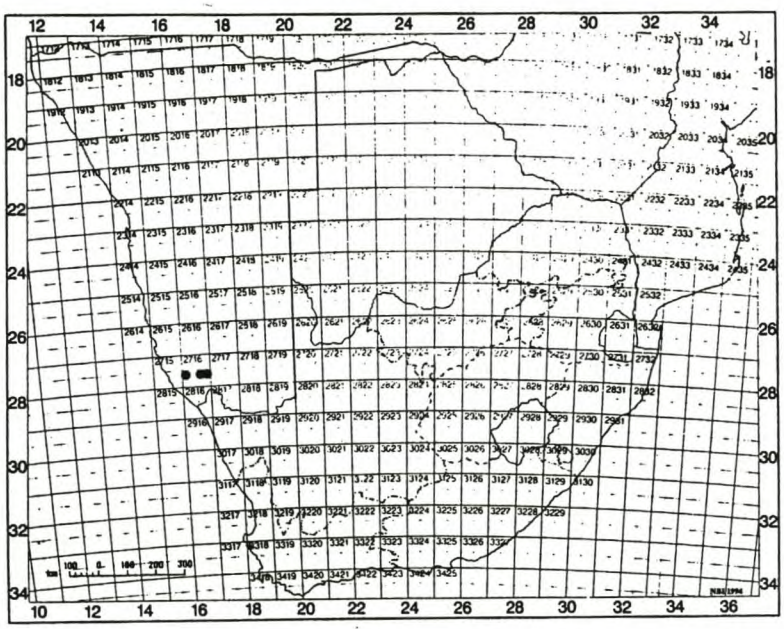


Figure 7.35.3. Geographical distribution of *Z. hirticaule*.

Specimens examined

–2716 (Witputz): Aurusberg, NW of Rosh Pinah (-CA), *Muller* 740 (WIND); Witputz Nord 22, 55 km N of Rosh Pinah (-DA), *Van Zyl* 3894 (B, NBG, PRE, S, WIND); Witputz Sud 31, N of Rosh Pinah (-DA), *Van Zyl* 3902 (NBG, PRE, WIND); *Oliver & Muller* 6406 (PRE); Kolke 84, N of Rosh Pinah (-DB), *Van Zyl* 4480 (NBG, WIND).

7.36 Zygophyllum calcicola *Van Zyl*, sp. nov., (§ *Capensia*), *Z. fulvo* habitu affinis sed pedicello perbrevi, 4–6 mm longo (in *Z. fulvo* semper longior, ad 25 mm longo), ovario 5-lobato, fructu vivo 5-lobato et 5-costato (ovarium *Z. fulvi* rotundatum, fructusque vivus rotundatus suturis inconspicuis, fructus siccus 5-lobatus). TYPE –

Western Cape: Botterkloof, N of Stilbaai, Riversdale district, *Van Zyl* 4277 (NBG, holo.; B, PRE, S).

Z. agulhanum *Schltr.* nom. nud. Agulhas, 27 April 1897, *Schlechter 10554* (Z!).

Erect, many-stemmed, woody shrub, reaching a height of 1.5 m and a diameter of 1.0 m. *Stems*: old stems brittle, nude, grey; young stems densely leafy, secund, flat or convex on ventral side, with prominent lateral ridges. *Leaves* opposite, bifoliolate, sessile, light green; rachis apex triangular, brown, 1.0 x 0.5 mm; leaflets articulate, obovate, apex rounded, mucronate, base cuneate, 13–19 x 4–8 mm; stipules widely triangular with a fleshy base and membranous, usually notched, apex, caducous, one on ventral side, one on dorsal side of stems, 2 x 2–3 mm. *Flowers* 1—4 together, axillary. *Pedicel* 4—6 mm long. *Sepals* 5, ovate or elliptic, apex acute or obtuse, some with membranous margins, 5–7 x 3–4 mm. *Petals* 5, posterior two patent and anterior three extended, greenish–white or yellowish, variously marked at base with brown or red, vaguely M–shaped blotches, with or without short, red veins, obovate, apex rounded, base with a long claw, 9–13 x 4–6 mm. *Nectar disc* fleshy, papillate, regularly 10-angled. *Stamens* 10; filaments terete, 5–7 mm; staminal scales 10, simple, obovate, apex truncate or obtuse, margins lacerate, with a sparse border of papillae on upper half, 2.0–3.0 x 1.0–1,5 mm, ½ the length of the filament. *Ovary* oblong or spheroid, 5–lobed; style terete, stigma simple. *Fruit* an oblong, 5–lobed, loculicidal capsule, each lobe with a central ridge where splitting will occur, 10–13 x 10–13 mm. *Seed* oblong, 1—3 per locule, 4 x 2.5 mm, dark brown with a white aril, testa smooth, glossy, producing brownish, structured mucilage with long spiral inclusions of uniform width when wet (Figure 7.36.1).

Diagnostic characters and affinities

Z. calcicola is recognized by its large size of 1.5 x 1.0 m (Figure 7.36.2.A), by its densely leafy, secund young stems; by its very short pedicels (4—6 mm in length; Figure 7.36.2.B—C) and by its fruits that are oblong and prominently 5-lobed and 5-ridged (Figure 7.36.2.D). *Z. calcicola* is allied to *Z. fulvum* with regard to vegetative

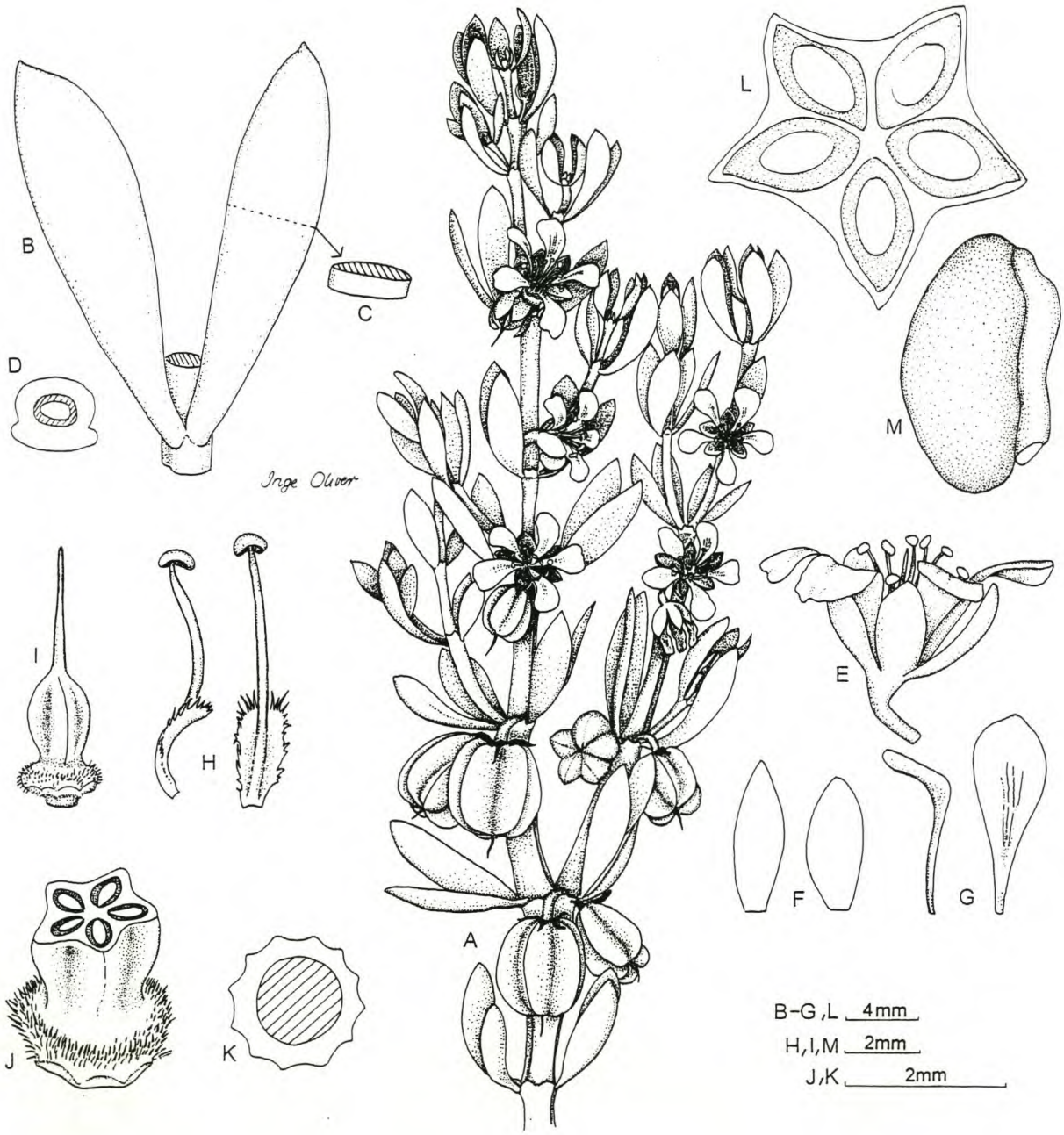


Figure 7.36.1. *Z. calcicola, Van Zyl 4277*. A, flowering and fruiting branch, life-size; B, obovate leaflets; C, cross section of leaflet; D, cross section of young stem; E, side-view of flower; F, sepals; G, petals; H, side-, and dorsal-view of staminal scale; I, ovary on papillate nectar disc; J, cross section of ovary; K, cross section of nectar disc; L, cross section of fruit; M, seed with aril.

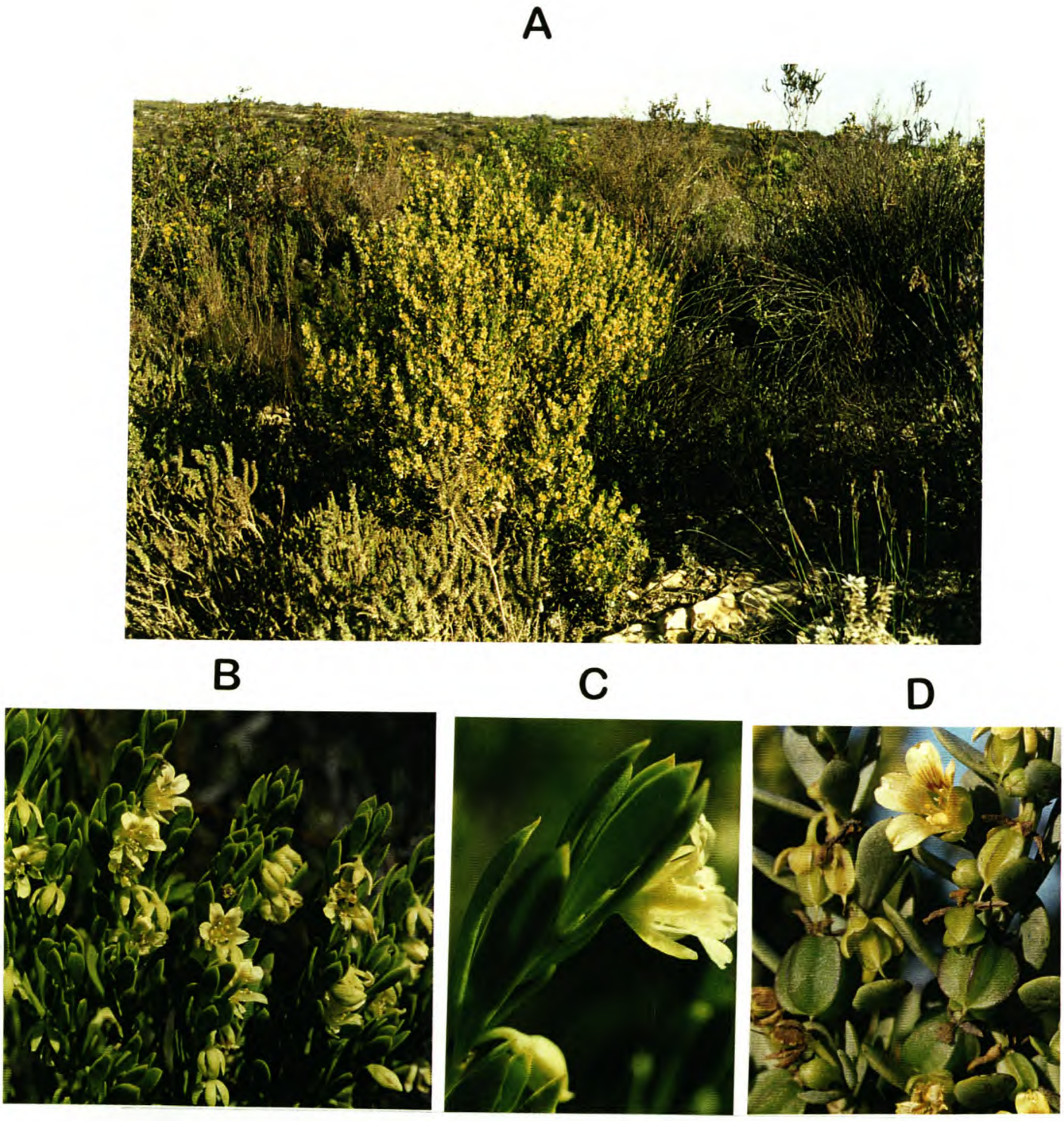


Figure 7.36.2. *Z. calcicola, Van Zyl 4277*. A, habit near Still Bay; B, twig with dense leaves and flower; C, side-view of flower; D, twig with flowers and immature fruits.

and floral morphology. They have similar sessile leaves and young stems with a flat ventral area and lateral ridges, they also have a similar filament to staminal scale ratio of 2 : 1, as well as a similar border of papillae on the surface of the scales. However, their stipules and fruits differ. The stipules of *Z. calcicola* are widely triangular, 2 x 2–3 mm in size, with a fleshy base and a membranous upper part with a notched apex. Only one stipule is present on the ventral side of the stems. The stipules of *Z. fulvum* are narrowly triangular, 1.0–4.0 x 0.5–2.0 mm in size, stiff and reflexed, with two on the ventral side of stems or rarely one, but then deeply notched. The mature fruits of *Z. calcicola* are oblong, prominently 5-lobed and 5-ridged and 10–13 x 10–13 mm in size, and those of *Z. fulvum* are 5-lobed, but not prominently so, with the lobes only vague visible, each lobe with a fine, central ridge which is often partly split open and 8–20 x 9–14 mm in size. Table 7.9 summarizes the characters of the species in § *Capensia* with sessile, not terete or linear leaves. The epithet *calcicola* refers to the preference of this species for limestone substrates.

Distribution and ecology

Z. calcicola is found in a narrow strip along the southern coastline of the Western Cape at low altitudes from Gansbaai in the west to Stilbaai in the east (Figure 7.36.3). The vegetation in which it occurs is classified as **Thicket Biome**: Dune Thicket (Lubke 1996) and **Fynbos Biome**: Laterite Fynbos and Limestone Fynbos (Rebelo, 1996). Dune Thicket occurs mostly on deep, regic dune sands with trees and shrubs dominant. Rainfall occurs during winter and is substantial, ranging from 900 to 1500 mm per year. The substrate for Laterite Fynbos is gravelly or lateritic and seasonally waterlogged and the vegetation is described as low shrubland with occasional tall shrubs. Limestone Fynbos occurs on calcareous, shallow sands overlying limestone and assosiated calcretes of the Bredasdorp Formation and the vegetation is dominated by large shrubs and reeds. Both Limestone Fynbos and Laterite Fynbos receive rainfall during winter, ranging from 350 to 600 mm per annum. Summers are hot and dry. *Z. calcicola* is a sunloving species and developes its typical habit with plumose branches and secund leaves in full sun. Flowering and fruiting occur from April to September. Large populations, scattered

along roadsides and in disturbed areas, occur including seedlings and young plants. This species is probably palatable because most specimens were seen outside grazing camps. Due to the large size of populations, there seems to be no threat to its survival at present.

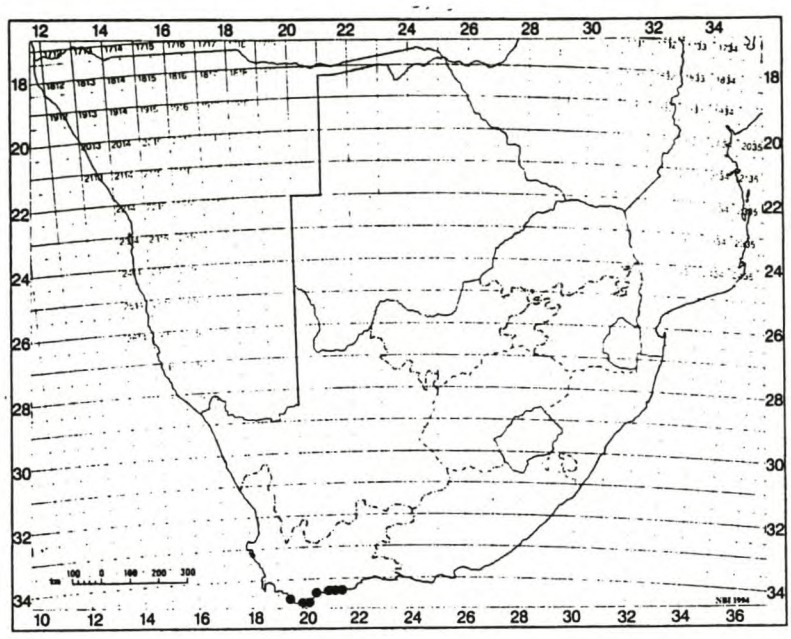


Figure 7.36.3. Geographical distribution of *Z. calcicola*.

Specimens examined

–3419 (Caledon): Gansbaai sand dunes (–CB), *Compton* 18238 (NBG); Between Springfield and Bosheuwel, SW of Bredasdorp (–DB), *Van Zyl* 4289 (B, NBG, PRE, S).

–3420 (Bredasdorp): NE of Hardevlakte, (–AD), *Oliver* 8527 (NBG, PRE, S); 2 km N of homestead, De Hoop Nature Reserve (–AD), *Burgers* 3128 (NBG, PRE); Potberg Nature Reserve, De Hoop (–AD), *Burgers* 1866 (NBG, PRE); Wydgelee, N of De Hoop Nature Reserve (–AD), *Van Zyl* 4288 (B, NBG, PRE, S); 2 km W of Duiwenhoks River Mouth (–BD), *O'Callagan et al. 384* (NBG, PRE); Cape Agulhas (–CC), *Schlechter SAM 10554* (BOL, GRA, PRE, SAM, Z); Near sea, Cape Agulhas (–CC), *Levyns 8853* (BOL).

–3421 (Riversdale): Sophies Shop, Vermaaklikheid (–AC), *Van Zyl* 4283 (NBG); Ridge below reservoir, Stilbaai (–AD), *Bohnen* 5752 (NBG, PRE); Olive Grove, Stilbaai (–AD), *Bohnen* 5822 (NBG, PRE); Stilbaai hills (–AD), *Barker* 5536 (NBG); Botterkloof, 7 km N of Stilbaai (–AD), *Van Zyl* 4277 (B, NBG, PRE, S).

7.37 Zygophyllum fulvum *L.* Species plantarum 1 : 386 (1753); Burm.f.: 12 (1768); Curtis: 47 t. 2184 (1787); Don: 771 (1831); Eckl. & Zeyh.: 97 (1835); Sond.: 358 (1860); Marloth: t. 35 (1925); Huysst.: 70 (1937); Adamson & Salter: 535 (1950); Batten & Bokelmann: 76, no. 9 (1966); Mason: 140, no. 1 (1972); Bond & Goldblatt: 437 (1984). ICONOTYPE: Burm.f.: Rariorum africanorum plantarum: 6, t. 3, f. 1. (1738). Additional features are illustrated by the epitype: Lower slopes on E side of Franschhoek Pass, *Van Zyl 3684* (NBG, PRE).

Zygophyllum semiteres *Eckl. & Zeyh.:* 97 (1835); Sond.: 359 (1860). TYPE - Western Cape: In lapidosis (altit. III) ad latera montium vallis "Tulbach" prope Waterfall (Worcester). Nov., *Ecklon & Zeyher 762* (S!, lecto, designated here, C!, KIEL, SAM!).

Zygophyllum alatum *E.Mey. in Drège*: 109 (1843) nom. nud. Western Cape: In Langvallei, *Drège 1038 or 1838* (K!).

Zygophyllum sessilifolium sensu Sims in Curtis: 47 : t. 2184 (1820).

Erect , decumbent or scrambling, many-stemmed shrub or shrublet reaching a height of 0.2—1.0 m and a diameter of 0.4—1.0 m. *Stems*: old stems nude, bark rough, gray, cracked; younger stems smooth, leafy, flat on ventral side and with prominent lateral ridges. *Leaves* opposite, sessile, bifoliolate; rachis apex triangular or narrowly triangular, stiff, 1–3 x 0.5–1.0 mm, reflexed, spinescent; leaflets articulate, glaucous or green, narrowly or widely obovate or elliptic, lamina flat or falcate, sometimes succulent with age, apex acute or obtuse, usually mucronate, base obtuse or narrowed, margins of most young leaves and sometimes older leaves scabrous, but less so with increasing age and succulency,10–30 x 3–15 mm; stipules narrowly triangular, stiff, reflexed, spinescent, two or rarely one only, and then deeply notched, on ventral side and one on dorsal side of stems, 1–4 x 5–2 mm. *Flowers* solitary or 2 together, axillary. *Pedicel 9*—20 mm long, elongating in fruit to 30 mm. *Sepals* 5, ovate, apex acute, some with membranous margins, 6–11 x 4–7 mm. *Petals* 5, obovate or widely obovate, 10–18 x 6–11 mm, apex rounded, emarginate, base with a short claw, cream-coloured, yellow or rarely white, variably marked at base with single or tiered, vaguely M- or V-shaped figures and streaky blotches in red, burgundy, or brown, always more so on two posterior petals. *Nectar*

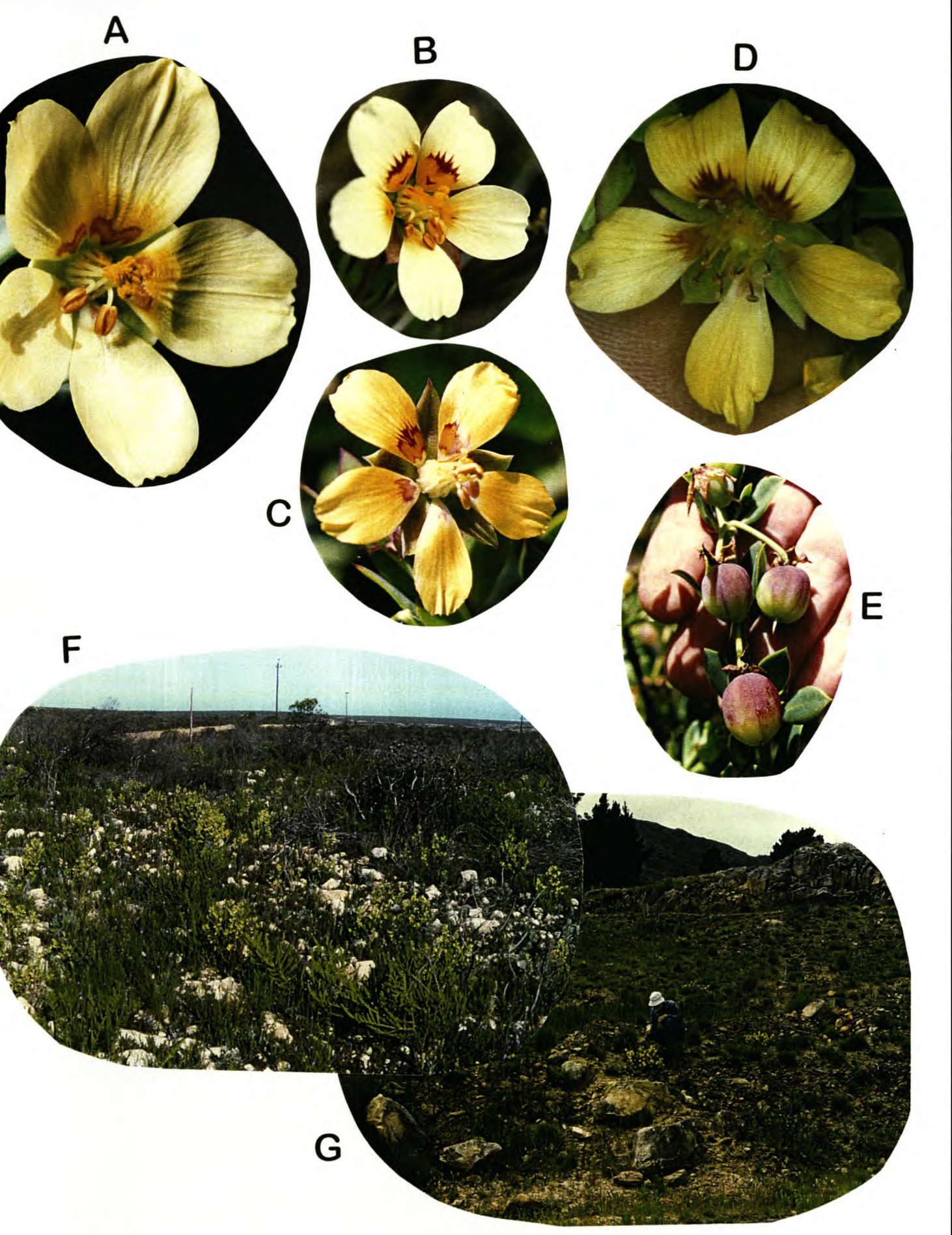


Figure 7.37.1. *Z. fulvum*. A—D, variation in flower markings. A, *Van Zyl 3673*; B, *Van Zyl 3937;* C, *Van Zyl 3986*; D, *Van Zyl 4023*; E, fresh, succulent fruits with visible sutures, *Van Zyl 3986*; F, common on recently burnt veld at De Hoop, *Van Zyl 4287*; common on recently burnt veld on Franschhoek Pass, *Van Zyl 3986*.

Figure 7.37.2. Variation in habit of *Z. fulvum*. A, robust shrub on Rooiberg Pass, *Van Zyl 4508*; Grazed, tall and erect shrub near Still Bay, *Van Zyl 4458*; C, decumbent shrublet on shales near Riversdale, *Van Zyl 4460*; D, scrambling habit near Robertson, *Van Zyl 4536*.

disc fleshy, papillate, regularly 10-angled. *Stamens* 10; filaments terete, 5—10 mm long; staminal scales 10, simple, oblong, margins with short lacerations, on ventral and dorsal surface bordered with dense or sparse papillae of uneven length, apex obtuse, 2–4 x 1–2 mm, ±1/2 the length of the filament. *Ovary* spherical; style terete; stigma simple. *Fruit* a subspheroid or oblong, drooping, loculicidal capsule; when fresh, tinted pink or burgundy on sunny side, spheroid or slightly 5-angled with 5 sutures visible, often succulent; when not completely mature (small, soft seeds inside) but dried out (the state found on most herbarium specimens) prominently 5-lobed, each lobe with a central ridge where spitting will occur; when mature (large, hard, mature seeds inside) and dry, 5-lobed with lobes less prominent and barely visible, each lobe with a fine, central ridge which is often partly split open at this stage, 8–20 x 9–14 mm. *Seed* oblong, 1—2 per locule, 3.5 x 2–2.5 mm, dark brown with white aril, testa glossy, smooth, producing pale brown, structured mucilage with long spirals of a uniform width when wet (Figures 7.37.1—2).

Diagnostic characters and affinities

Z. fulvum is recognized by its young stems, which are flat on the ventral side with prominent lateral ridges, and with two stipules on the ventral side and only one on the dorsal side of stems, by its sessile, bifoliolate leaves with obovate or elliptic leaflets, by its staminal scales with lacerated margins bordered with papillae of uneven length on both the ventral and dorsal side. It is related to the species in § *Capensia* with sessile leaves and flat laminas. With regard to floral morphology it shows a closer affinity to *Z. cuneifolium*, *Z. hirticaule, Z. calcicola* and *Z. porphyrocaule*, because of the similarity in their staminal scales. All four species have a border of papillae on the ventral surfaces of their scales as well as lacerated margins and a filament to scale ratio of 2 : 1. The epithet *fulvum* is Latin for dull yellow and probably refers to the flower colour which is not a dull yellow but usually a sparkling, bright yellow . Table 7.9 summarizes the characters of the species in § *Capensia* with sessile, not terete or linear leaflets.

Distribution and ecology

Z. fulvum is a common species with a large distribution area. It occurs on the lower slopes of most of the mountains of the Cape Fold Belt as well as on the coastal flats reaching the shores, from Vanrhynsdorp in the north to the Cape Peninsula in the south and to Port Elizabeth in the east (Figure 7.37.3). The vegetation in which it occurs is classified as **Thicket Biome:** Dune Thicket (Lubke 1996) on deep, regic dune sands close to the shore with winter rainfall, ranging from 900 —1500 mm per year. The temperatures are moderate throughout the year with short periods of extremes now and then. *Z. fulvum* is also well represented in both the Renosterveld and Fynbos divisions of the **Fynbos Biome**: Central Mountain Renosterveld, West Coast Renosterveld and South & South-West Coast Renosterveld, Mountain Fynbos, Grassy Fynbos, Limestone Fynbos and Sand Plain Fynbos (Rebelo, 1996). The Renosterveld receives rain during winter, ranging from 250—600 mm per annum, with autumn and spring showers towards the east of its range. It occurs on substrates usually derived from Malmesbury, Bokkeveld and Kango Group shales. The Fynbos also receives rain during winter, ranging from 200—2000 mm per annum. The biome occurs mainly on sands derived from the Cape Supergroup, which is calcareous sands overlying limestone and deep acidic sands of the West Coast.

Populations are large and consist of scattered individuals dispersed over large areas. Grazing damage is insignificant. Seedlings or young plants are usually rare, but occur in abundance on recently burnt areas (Figure 7.37.1.F—G). The extended range of *Z. fulvum* represents a large variety of ecological niches, which explain the variation found in its habit (Figure 7.37.2.A—D). Erect shrubs of up to 1.0 m high are usually found on sandstone; compact, decumbent shrublets of 0.2 m high usually on calcareous soils and lanky, scramblers with long, flexible branches growing over and into nearby shrubs usually on shale. Branches can be densely-leafed or sparsely-leaved, depending on seasonal changes and the accompanying growth rate. Although there is a considerable variation in the habit and vegetative morphology of this species, the basic flower and fruit morphology remains constant and the subdivision of this species was not considered necessary. Flowers and fruits are found from May to January with a peak during spring. Because its habitat is mainly in mountainous areas where grazing and other farming activities are negligible, *Z. fulvum* is not considered threatened at present.

Common name: spekbos.

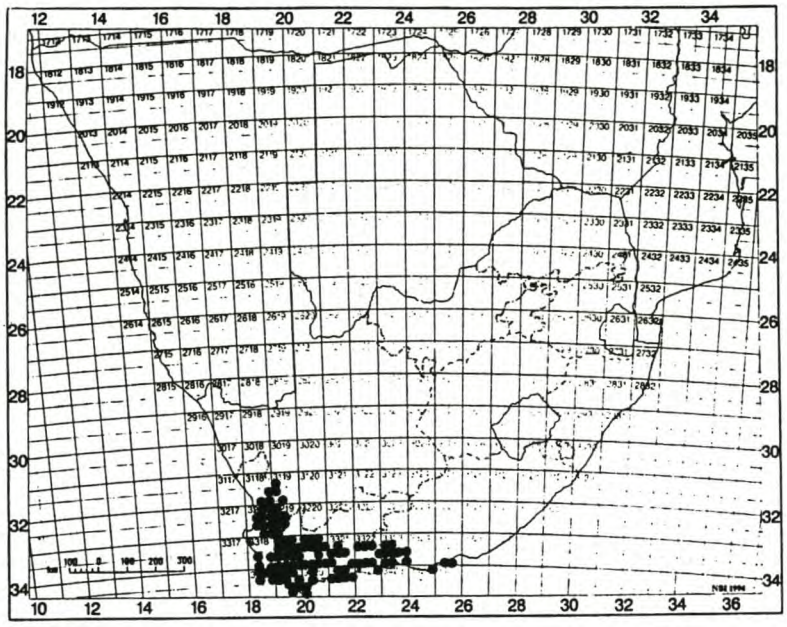


Figure 7.37.3. Geographical distribution of *Z. fulvum*.

Specimens examined

–3118 (Vanrhynsdorp): Summit of Kobe Pass (–DB), *Hall 4515* (NBG, PRE); Klaver (–DC), *Lewis 2945* (SAM); Gifberg (–DC), *Phillips 7609* (NBG); Nardouw Kloof (–DC), *Stokoe s.n.* (SAM 63619); High plateau in front of mountains at Klaver (–DC), *Andreae 504* (NBG); Above Traval, Olifantsrivier Valley (–DC), *Rourke 549* (NBG); Near Muggiedraai (–DD), *Van Zyl 3668* (NBG, PRE); Wet area on plateau on top of Gifberg (–DD), *Zietsman 1146* (PRE).

–3119 (Calvinia): Rocky ridge on Glenridge, Niewoudtville (–AC), *Hugo 514* (NBG); Between Nieuwoudtville and Oorlogskloof (–AC), *Leipoldt 4034, 4031* (BOL); Half way dawn Vanrhyns Pass (–AC), *Lewis 19815* (BOL); Top of Vanrhyns Pass (–AC), *Taylor 2906* (NBG); Ridges N of dam on Lokenburg (–CA), *Leistner 337* (PRE); Top of Botterkloof Pass (–CD), *Johnson 559* (NBG); *Compton 20897* (NBG).

–3218 (Clanwilliam): Sandy slopes at Elandsbaai (–AD), *Metelerkamp 206* (BOL); Uitkomst, Clanwilliam (–BA), *Bond 1071* (NBG); 14 km W of Clanwilliam on road to Lambertsbaai (–BA), *Van Zyl 4302, 4297* (NBG); *Lewis 2946* (SAM); *Salter 7552* (BOL); 3.5 M NE of Graafwater (–BA), *Acocks 19653* (PRE); 20 km N of Clanwilliam next to N7 (–BB), *Van Zyl 4107* (NBG, PRE); Nardouskloof road (–BB), *Van Zyl 3667* (NBG, PRE); Road shoulders at Redelinghuys (–BC), *Van Zyl 4248* (BOL, NBG, PRE); 40 km N of Citrusdal next to N7 (–BD), *Van Zyl 4300* (NBG); Nuwemoed (–BD), *Van Zyl 4271* (NBG); Arbeidsgenot, on gravel road between Citrusdal and Clanwilliam (–BD), *Van Zyl 3592* (BOL, GRA, NBG, PRE); Base of Tafelberg, SW of Redelinghuys (–CB), *Van Zyl 4023* (NBG, PRE); Near Kleinberg, SW of Paleisheuwel (–DA), *Van Zyl 4267* (BOL, GRA, NBG, PRE); Plateau on

Kapiteinskloof, Piketberg (–DA), *Pillans 7825* (BOL); N side of Grey's Pass (–DB), *Levyns 1343* (BOL); *Van Zyl 3672* (BOL, NBG, PRE); *Acocks & Hafström 766* (PRE); Between The Rest and Modderfontein (–DC), *Howes 232* (PRE); Koggelmanderskop, on Piketberg (–DC), *Van Zyl 4258* (NBG); Between Vergesig and Helderview on Piketberg (–DC), *Van Zyl 4257* (NBG); De Hoek, Piketberg (–DD), *Lewis 2947* (SAM); *Barker 4678* (NBG); *Compton 14996* (NBG).

–3219 (Wuppertal): Citadel Kop, Clanwilliam (–AA), *Compton 24280* (NBG); Pakhuis Pass (–AA), *Leipoldt 4400* (BOL); *Compton 4339, 6924* (BOL, NBG); Slopes of Tafelberg, Cedarberg (–AC/CA), *Esterhuysen 8088* (BOL); Mountain slopes near Algeria (–AC), *Galpin 10534* (PRE): E side of Uitkykpas, Cedarberg (–AC), *Van Zyl 3965* (BOL, NBG, PRE); Near Algeria Camp Site (–AC), *Hugo 642* (NBG); *Bos 500* (NBG, PRE); NW slopes near Algeria (–AC), *Low 698* (NBG); *Levyns 2258* (BOL); Sederhoutskloof, Cedarberg (–AC), *Andrag 244* (NBG); Middelberg, Cedarberg (–AC), *Andrag 97* (NBG); Near Krakadouw Forest Station (–AC), *Thorne s.n.* (SAM 53107); Matjiesrivier, Cedarberg (–AD), *Wagener 158* (NBG); Kromrivierkloof above The Oaks (–CA), *Taylor 10639* (NBG); Elandskloof, Ceres (–CA), *Compton 8700, 16213* (NBG); Near Warm Baths, Olifantsrivierberge (–CA), *Pearson 7229* (NBG); Krommerivier, S Cedarberg (–CB), *Esterhuysen 20504* (BOL); *Leighton 21579* (BOL); E slopes of Cardouw Pass (–CC), *Barker 8119* (NBG); Grootfontein, Porterville (–CC), *Van Zyl 3745* (BOL, NBG, PRE); Grasruggens, Porterville (–CC), *Van Zyl 3111* (NBG).

–3318 (Cape Town): Hollows in dunes at Strandfontein (–BA), *Compton 13703* (NBG); Dunes on Cape Flats near Mowbray and Faure (–CD), *Esterhuysen 23145* (BOL); NW aspect on Paarlberg Nature Reserve (–DB), *Van Schalkwyk A3* (NBG); *Compton 22949* (NBG); *Kruger M 144* (NBG); Stellenbosch (–DD), *Gillett 856* (NBG); Roadsides in Jonkershoek (–DD), *Malherbe 17* (NBG); Blaauwklip, Stellenbosch (–DD), *Gillett 609* (NBG); N ridge on Stellenboschberg (–DD), *Taylor 7142* (NBG, PRE); Fransmanskraal, Stellenbosch (–DD), *Boucher 4105* (NBG).

–3319 (Worcester): Winterhoek, Tulbach (–AA), *Zeyher 1189* (SAM 14502);
5 km N of Tulbach on road to Winterhoek State Forest (–AA), *Mauve & Hugo 56* (NBG, PRE); N ridge of Gydoberg (–AB), *Oliver 5103* (NBG, PRE); *Leipoldt 4033* (BOL); W base of Houdenbeksberg (–AB), *Van Zyl 4148* (NBG, PRE); *Adamson s.n.* (BOL 49196); Gydo (–AB/AD), *Leipoldt 4032* (BOL); Mountains near Tulbach Kloof (–AC), *Stokoe s.n.* (SAM 66956); Near Tulbach (–AC), *Bolus s.n.* (PRE 45903); Roadside near Gouda (–AC), *Barker 9215* (NBG); S side of New Kloof, Tulbach (–AC), *Gillett 391* (NBG); Tulbach, near Waterfall (–AC), *Eckl. & Zeyh. 762* (C, KIEL, S, SAM); 8 M N of Ceres (–AD), *Maguire 1760* (NBG); Mitchell's Pass near Ceres (–AD), *Bolus 5323* (BOL); *Bolus 3087* (NBG); *Walters 238* (NBG); *Gillett 343* (NBG); Hillside between La Plaisante and White bridge in Mitchell's Pass (–AD), *Walters 100* (NBG); Watervalsberg, Kareevlakte (–BA), *Grobler 525* (NBG); Lower SE slopes of Prospect Peak, Hex River Mountains (–BC), *Esterhuysen 15899* (BOL); Karoo Poort (–BC), *Compton 11799, 22931* (NBG); *Levyns 4642* (BOL); *Leighton 21197* (BOL); Near Verlorenvlei, Ceres (–BC), *Levyns 1003* (BOL); De Doorns (–BC), *Marloth 1966* (PRE); Kareekloof, Worcester (–BC), *Olivier 5* (NBG); Kloofs in Hex River valley (–BD), *Tyson 669* (SAM); Hex River Pass, Worcester (–BD), *Barker 7456* (NBG); Hawequas State Forest in Du Toits Kloof Pass (–CA), *Forsyth 292* (NBG, PRE); W slopes of Badsberg, Worester (–CA), *Taylor 5368* (NBG); Karoo Garden veld (–CB), *Dobay 18* (NBG); W base of Franschhoek Pass (–CC), *Van Zyl 3653* (NBG, PRE); *Van*

der Merwe 411 (NBG); *Van Zyl 3650* (NBG); *Van Zyl 3986* (BOL, GRA, NBG, PRE); *Rodin 3083, 3084* (BOL); *Bolus s.n.* (BOL 49322); *Compton 20201* (NBG); *Phillips 1067* (SAM); *Emdon 62* (NBG, PRE); *Boucher 2261* (NBG), PRE); *Van Wyk 2055* (PRE); *Marsh 651* (NBG, PRE); *Leighton 2872* (BOL); Zachariashoek, Kasteelkloof, La Motte Forest Station (–CC), *Viviers 554, 626* (NBG); *Lamb 96* (NBG); *Haynes 708, 841* (NBG, PRE); Wemmershoek (–CC), *Compton 10137* (NBG); Basis of Kroonland Peak, High Noon, Villiersdorp (–CD), *Van Wyk 427* (NBG, PRE); Boschjesveld Mountains (–CD), *Stokoe s.n.* (SAM 69018); Doringkloof, S foothills of Voetpadsberg (–DA), *Morley 404* (NBG, PRE); *Van Wyk 67* (NBG); Amandalia, NW of Robertson (–DA), *Van Zyl 4125, 4494* (BOL, GRA, NBG, PRE); *Van Zyl 3673* (NBG, PRE); Nuy, roadside between Sandhills and Worcester (–DA), *Walters 1865* (NBG); De Wet (–DA), *Theron 15* (NBG); Roadside next to cottage on Patryskloof (–DA), *Hugo 2391* (NBG, PRE); Vinkrivier, Robertson (–DA), *Van Breda 4122* (PRE); Pass between Montagu and Koo (–DB), *Lewis 6039* (NBG); Rooihoogte Pass (–DB), *Van Zyl 3683* (NBG, PRE); Eendracht, Montagu (–DB), *Walgate s.n.* (BOL 23998); *Lewis 1698* (SAM); Near bridge S of Robertson on road to McGregor (–DD), *Van Zyl 3676* (NBG); Sandy hills on McGregor road (–DD), *Tromp 15a* (NBG); Boesmanskloof Pass near McGregor (–DC/DD), *Lewis 6073* (NBG); Rheebokskraal, near McGregor (–DD), *Van Zyl 4461, 4462, 4464* (NBG); Karoo hills at Robertson (–DD), *Galpin 9896* (PRE); Near Robertson (–DD), *Barker 5392* (NBG); 8 M from Robertson on road to McGregor (–DD), *Marsh 976* (NBG); On Karoo hill 6 M from Robertson on Worcester road (–DD), *Story 2898* (PRE); 22 km NE of Nuy on gravel road to R60 (–DD), *Drÿfhout 4195* (NBG); A few M S of Robertson (–DD), *Levyns 10148* (BOL); Olifantsdoorn, after Strykhoogte, S of Robertson (–DD), *Van Zyl 3678, 3679, 3680* (NBG, PRE); E foothills of Sandberg, SE of Robertson (–DD), *Van Zyl 4469* (NBG).

–3320 (Montagu): Voetpadsberg (–AA), *Barker 7497* (NBG); Cabidu, Laingsburg (–AB), *Barker 1353* (NBG); Quartsite hill at Tweedside Railway Siding (–AB), *Marloth 10846* (PRE); Hills near Touws River (–AC), *Levyns 860* (BOL); Witwaterspoort between Tweedside and Konstabel Sidings (–AD), *Van Zyl 3946* (NBG); Witteberg (–BC), *Compton 2677* (BOL); *Compton 3275* (NBG); *Compton 3551* (BOL); *Compton 4059* (BOL, NBG); *Compton 7961* (NBG); *Compton 12140* (NBG); *Compton 13979* (NBG); Between Bantams Siding and Radio tower on Witteberg (–BC), *Van Zyl 3973* (NBG, PRE); Keurkloof, Montagu district (–BC), *Lewis s.n.* (BOL 49210); Wittepoort, Laingsburg (–BD), *Compton 11823* (NBG); Near top of Suikerdrifkloofpas (–BD), *Van Zyl 3713* (NBG); Mountain in front of Montagu Baths (–CC), *Anon 158* (BOL); Eendracht, Montagu (–CC), *Compton 18371* (NBG); Kochmanskloof, Montagu (–CC), *Taylor 368* (BOL); *Barker 5415, 8262* (NBG); *Compton 18479* (NBG); *Lamb 279* (SAM); *Salter 1100* (BOL); S slopes of mountain to the N of Montagu Baths (–CC), *Mitchell 158* (PRE); Olifantsberg, Montagu (–CC), *Viviers 426* (NBG); Hills near Bonnievale (–CC), *Levyns 4571* (BOL); Scheepersrust, Montagu (–CD), *Morris 189* (NBG); E end of Anysberg (–DA), *Van Zyl 3319* (NBG); 3 M from Barrydale into Tradouw Pass (–DC), *Marsh 676* (NBG); Tradouw Pass (–DC), *Sidey 1791* (PRE); Langeberg East MCA near Barrydale (–DC), *Van der Merwe 177* (NBG); Witbooisrivier in district Barrydale (–DD), *Van der Walt s.n.* (NBG).

–3321 (Ladismith): Between Vleiland and Seweweekspoort turn off (–AD), *Van Zyl 3936* (BOL, NBG); N entrance to Seweweekspoort (–AD), *Taylor 9364* (NBG, PRE); *Van Zyl 3615, 3616* (BOL, GRA,

NBG); *Phillips 1407* (SAM); Elandsberg = Torenberg, Ladismith (–AD), *Wurtz 1076* (NBG); Near Hoeko, Ladismith (–AD), *Van Zyl 3690* (NBG, PRE); W side of Bosluiskloofpas (–AD), *Van Zyl 3697* (NBG); S slopes of Gamka Mountain (–BC), *Boshoff P192* (NBG); Waterkloof N of Nuyswagendrift, Ladismith (–AD), *Schelpe 853* (BOL); Rietfontein, SE of Touwsberg, Ladismith (–CA), *Germishuizen 6916A* (PRE); Near water trough in Noukloof Nature reserve (–CA), *Laidler 160* (NBG, PRE); Arrarat se pad on Roodeberg (–CB), *Marshall 80* (NBG); Poort 6 km E of Ladismith (–CB), *Taylor 8967* (NBG); N side of Rooiberg (–CB), *Wurts 1268* (NBG); *Steyn 296* (NBG); E ridge of Bailey Peak (–CB), *Oliver 5440* (NBG); N side of Garcia's Pass (–CC), *Johnson 130* (NBG); Muiskraal in Little Karoo (–CC), *Bohnen 8249* (NBG, PRE); Flats near Muiskraal (–CC), *Muir 2979* (PRE); *Levyns 2123* (BOL); *Phillips 371* (PRE, SAM); N base of Kampsehe Berg near Garcias Pass (–CC), *Galpin 3804* (GRA, PRE); Near top of Gysmanshoek Pass (–CC), *Hugo 2724* (NBG, PRE); Garcias Pass (–CC), *Morris 244* (NBG); Roodeberg Pass (–DA), *Barker 5504* (NBG); *Acocks 14617* (PRE); Near summit of Rooiberg (–DA), *Mauve, Van Wyk & Pare 24, 33* (NBG, PRE); *Lewis 4824* (PRE, SAM); *Lewis 4820* (SAM); *Morris 224* (NBG); *Marshall 94* (NBG); *Van Zyl 4508* (NBG, PRE); Near top of small pass on Kleinfontein (–DD), *Laidler 563* (NBG, PRE).

–3322 (Oudshoorn): Bassonsrust, N of Oudshoorn (–AC), *Van Zyl 3621* (BOL, GRA, NBG, PRE); Slopes of Swartberg Pass (–AC), *Bolus 11451* (BOL, PRE); Wilgerdal, E of Prins Albert (–AD), *Van Zyl 4536* (NBG); Eikenkraal, between Prins Albert and Klaarstroom (–BC), *Leipoldt s.n.* (BOL 49311); N slopes of Jonkersberg, Outeniquas (–CC), *Bond 1747* (NBG); 4 M WNW of Camfer Station, George (–CD), *Acocks 22864* (PRE); Along the road to Klipdrift, 6.8 m from Doorn River (–CD), *Fourcade 44710* (BOL); *Fourcade 5685* (BOL); *Van Zyl 3937* (BOL, NBG, PRE); N end of Eseljagpoort (–DB), *Thompson 1329* (NBG); Kirstenheim W of Lauding (–DB), *Oliver 3590* (NBG); S slopes in Roode Els Kloof, Kammanassie Mountains (–DB), *Matthews 281* (PRE); Matjiesdrift, George (–DC), *Levyns 10564* (BOL).

–3323 (Willowmore): S slopes of Slypsteenberg (–AC), *Esterhuysen 6298* (BOL); E slopes of Anthoniesberg (–AD), *Esterhuysen 24941* (BOL); Behind School in Avontuur (–CA), *Van Zyl 3635* (BOL, GRA, NBG); Hills near Avontuur (–CA), *Fourcade 1680* (NBG); 11 km S of Uniondale (–CA), *Van Zyl 3636* (NBG, PRE); 3 km W of Uniondale (–CA), *Van Zyl 3627* (BOL, GRA, NBG); Braamfontein, 2 km S of Avontuur (–CA), *Van Zyl 3634* (NBG); Lower foothills of Kouga Mountains (–CB), *Taylor 890* (NBG); Ongeleë, E of Avontuur (–CB), *Stirton 6338* (PRE); N of Diepwalle in Prins Alfred's Pass (–CC), *Meyer 316* (PRE); Hills near Misgund (–CD), *Fourcade 4236* (BOL); *Esterhuysen 6963* (BOL); Kouga near Misgund (–CD), *Compton 7500* (NBG); Boskloof, Baviaanskloof (–DA), *Hugo 1443* (NBG); NE of Smutsberg, Kouga Mountains (–DB), *Thompson 2001* (NBG); Willowmore - Studtis, Baviaanskloof (–DB), *Manson 65* (NBG); The Heights, N slopes of Tsitsikamma State Forest (–DD), *Kruger 1634* (NBG); Rocky hill N of Joubertina (–DD), *Fourcade 2687* (NBG).

–3325 (Port Elizabeth): Sandy hills near Bethalsdorp (–CD), *Zeyher 84* (SAM 29997); Gravel pit in Duncan Street, Port Elizabeth (–DC), *Walters 2055* (NBG); Open, sandy flats, Port Elizabeth (–DC), *Bokelmann Pl 76, f. 9* (NBG); *Cruden 443* (BOL, GRA); Baakens Valley (–DC), *Long 228* (GRA,

PRE); Dodd's farm, Baakens Valley (–DC), *Olivier 1068* (NBG, PRE); Walmer, Port Elizabeth (–DC), *Cruden 318* (PRE); Golf Course, Port Elizabeth (–DC), *Britten 1781* (GRA, PRE).

–3418 (Simonstown): Sandy beach at Muizenberg (–AB), *Schlechter 1256* (GRA); *MacOvan 539* (BOL, PRE, SAM): *Wolley Dod 3683* (BOL); Sandy places at Fish Hoek (–AB), *Thode 7909* (NBG); Rietveld, Cape of Good Hope Nature Reserve (–AD), *Taylor s.n.* (NBG); Kromrivier, Cape of Good Hope Nature Reserve (–AD), *Taylor 7120* (NBG, PRE); Maclear Beach, Cape of Good Hope Nature Reserve (–AD), *Van Zyl 3967* (BOL, GRA, NBG); Between Fransdam and main road to Cape Point (–AD), *Taylor 6509* (NBG); In dense vegetation near Cape Point (–AD), *Van Zyl 4150* (NBG, PRE); Smitswinkel flats (–AD), *Saxton s.n.* (SAM 29994); On paths to Owlet Hill (–AD), *Taylor 7134* (NBG); Isoetes Vlei (–BA), *Gubb 113a* (NBG); Reiersvlei near Mitchell's Plain (–BA), *Esterhuysen 35476* (BOL); W of Macassar township (–BA), *Low 401* (NBG); Strandfontein (–BA), *Gillett 541* (NBG); *Pillans 10612* (BOL); Retreat on Cape Flats (–BA), *Lamb 1084* (SAM); Sir Lowry's Pass (–BB), *Guthrie 2014* (BOL); *Jordaan 1172* (NBG); *Barker 704* (NBG); *Johnson 96* (NBG); *Compton 16531* (NBG); Top of Hottentotshollandbergen, W of Sir Lowry's Pass (–BB), *Bos 640* (NBG); Hottentottshollandskloof, Hauhoek (Stellenbosch), (–BB), *Eckl. & Zeyh. 764* (TCD); Flats on Vergelegen (–BB), *Barker 9083* (NBG); Grabouw State Forest (–BB), *Richardson 21* (NBG); Research site in Kogelberg State Forest (–BD), *Van Wilgen 76* (NBG); *Durand 40* (NBG); Near bridge, Kogelbaai (–BD), *Boucher 480* (NBG); Base of mountains near Palmiet Strand (–BD), *De Vos 1064* (NBG).

–3419(Caledon): Lower slopes on E side of Franschhoek Pass (–AA), *Van Zyl 3684* (NBG, PRE); Palmier River farm, Elgin (–AA), *Winkler 23* (NBG); Palmier River valley, Grabouw (–AA), *Bolus 4113* (BOL); *Guthrie 4261* (NBG); Slopes of Houhoek (–AA), *Levyns 11337* (BOL); Bor River Pass (–AA), *Compton 18511* (NBG); Near Bot River (–AA), *Salter 4654* (BOL); Slopes of Swartberge, Caledon (–AB), *Theron 5* (NBG); *Esterhuysen 18951* (BOL); *Zeyher 2144* (SAM 29996); Northcliff, Fernkloof Nature Reserve (–AC), *Burman 871* (BOL); Volmoed on Hemel en Aarde road (–AD), *Van der Zeyde 76 - 83* (NBG); Gravel pit on mountain slopes (–AD), *Van Wyk 2094* (PRE); Between Hermanus and Stanford (–AD), *Gillett 4167* (BOL); Klynrivierskloof (–AD/BB), *Zeyher 2143* (SAM 29999); Hauhoek and Klynrivier (–AD), *Ecklon & Zeyher 764* (SAM 29999); Upper NE slopes of Galgeberg (–BA), *Van Jaarsveld 6454* (NBG); Perdekop, Greyton (–BA), *Viviers 429* (NBG); Keeromskloof, Salmonsdam Nature Reserve (–BC), *Hugo 2636* (NBG, PRE); Kogel Bay (–BD), *Compton 20082* (NBG); Coastal flatland at Franskraal (–CB), *Van der Zeyde 69 / 83* (NBG, PRE); Langbosch, Gansbaai (–CB), *Walters 1494* (NBG); Danger Point, Caledon (–CB), *Maguire 5* (NBG); Baviaansfontein near Die Kelders (-CB), *Thompson 1205* (NBG, PRE); Near Wolffontein, between Stanford and Gansbaai (–AD), *Van Zyl 4296* (BOL, GRA, NBG, PRE); Between Blomhuis and Bleskloof, NE of Pearly Beach (–DA), *Hugo 2677* (NBG, PRE); Hills near Elim (–DA/DB), *Bolus s.n.* (BOL 49201); Coastal flatland at Buffelsjag (–DA/DC), *Van der Zeyde 55 / 83* (NBG).

–3420 (Bredasdorp): 10 M from Heidelberg to Witsand (–AB), *Marsh 831* (NBG, PRE); Bontebok Park, Swellendam (–AB), *Liebenberg 6460* (NBG, PRE); *Brynard 250* (PRE); 1 km W of Ouplaas, De Hoop Nature Reserve (–AD), *Burgers 1431* (NBG); Driefontein, N of De Hoop Nature Reserve (–AD),

Van Zyl 4287 (BOL, GRA, NBG, PRE); 3 km NE of Bredasdorp on road to Swellendam (–CA), *Thompson 3240* (NBG, PRE); Hills near Cape Agulhas (–CC), *Schlechter 10562* (GRA, PRE, Z).

–3421 (Riversdal): Riversdale Wildreservaat (–AB), *Taylor 7731* (NBG); Riversdale (–AB), *Glover 15511* (BOL); *Muir 2705* (BOL); Sandy flats near Zoutpan (–AB), *Muir 3338* (BOL); 2 km from N2 on road to Still Bay (–AB), *Van Zyl 4456* (GRA, NBG, PRE); N of Vermaaklikheid on road to Heidelberg (–AC), *Van Zyl 4465* (BOL, NBG, PRE); Dune summit next to sea at Puntjie (–AC), *Botes 236* (NBG); On gravel road on W side of Kafferkuilsrivier on road to Grootfontein (–AD), *Van Zyl 4460* (BOL, GRA, NBG, PRE); Stilbaai hill W of bridge (–AD), *Bohnen 4145* (NBG); Stilbaai State Forest (–AD), *Britton 29* (NBG); Stilbaai ridge below reservoir (–AD), *Bohnen 5753* (NBG); S of Riversdale on road to Riethuiskraal (–AD), *Van Zyl 4458* (BOL, NBG, PRE); Kleinejongensfontein (–AD), *Botes 281* (NBG); Botteliersfontein near Albertinia (–BA), *Muir 1585* (BOL); Elandskop, between Albertinia and Yzervarkfontein (–BC), *Muir 904* (PRE); Plateau at Gouritz Mouth (–BD), *Bohnen 7719* (NBG); 3 km N of The Fishreries (–BD), Hugo 1265 (NBG).

–3422 (Mossel Bay): Ruigtevlei, Knysna (–BB), *Fourcade 1562* (BOL, NBG, PRE).

–3424 (Humansdorp): Humansdorp (–BB), *Rogers 3110* (PRE); 5 M from Humansdorp on road to Hankey (–BB), *Fourcade 5555b* (NBG).

Unknown or no precise locality: Knechtsvlakte and Sandveld, *Leipoldt 4030* (BOL, PRE); Olifantrivier, *Schlechter 8001* (PRE); *Zeyher s.n.*(SAM 14500); Between Berg Valley and Clanwilliam, *Lewis 2944* (SAM); On mountain slopes near Stellenbosch, *De Villiers s.n.* (STE 31750 in NBG); Wild Flower Show at Ceres, *Compton 6323* (NBG); Ceres Road, *Schlechter 8986* (PRE); Ceres, *Loubser 785* (BOL); Pienaarskloof, Worcester, *Taylor 6470* (NBG); Hex River, *Tyson 669* (SAM 5895); Hill slopes near Bonnievale, *Van Breda & Joubert 1944* (PRE); Breede River between Tulbach and Worcester, *Bolus 2738* (SAM); Breede River, *Leipoldt s.n.* (STE 25977 in NBG); Highlands, Caledon, *Downing 353* (NBG); Between Caledon and Warmbaths Hotel, *Gillett 1105* (NBG); Boesmanspad, Swellendam, *Joubert s.n.* (STE 10231 in NBG); N slopes of Langeberg, *Levyns 6510* (BOL); S slopes of dry hills near Ladismith, *Levyns 2075, 7395* (BOL); Slopes at foot of Langeberg near Leeuwrivierberg , *Esterhuysen 24567* (BOL); Uitenhage district, *MacDonald 1* (GRA); Upper Keurboomsrivier in Longkloof, *Esterhuysen 10850* (BOL); On mountain at Humansdorp, *Wagner s.n.* (STE 17124 in NBG); Kruisfontein Mountains, Humansdorp, *Galpin 3803* (PRE); Humansdorp, S.W. Coast region, *Rogers 3110* (GRA); No locality, *Drège s.n.* (BOL 49128); Stellenbosch, anon. ((TCD); CBS 1847, Alexander (TCD); Witzenberg, Tulbach, anon. (TCD); Stellenbosch Mountain, Nov 2, anon. (TCD).

7.38 **Zygophyllum porphyrocaule** *Van Zyl*, sp. nov., (§ *Capensia*), *Z. swartbergensi* affinis habitu magno plus quam 1.0 m altitudine, sed foliolis obovatis, squamis staminalibus marginibus superis longe laceratis, paginaque

ventrali papillata differt (non foliolis ellipticis, squamis staminalibus marginibus breviter dentatis, ut in *Z. swartbergense).* TYPE - Western Cape: Between Hugo and Kleinstraat Sidings, NE of De Doorns, *Van Zyl 3613* (NBG, holo., BOL, K, S).

Rounded, multi-stemmed, woody shrub, sparsely leafy and with internodes visible, often with drooping branches, reaching a height of 1.5 m and a diameter of 1.5 m. *Stems*: old stems leafless, able to resprout, bark dark grey, rough; young stems reddish-brown, obviously flexuous, flat on ventral side and with lateral ridges. *Leaves* opposite, sessile, bifoliolate; rachis apex triangular, reflexed; leaflets articulate, dark green, obovate, apex rounded, not mucronate, base cuneate, 10–14 x 3–5 mm; stipules triangular, reflexed, caducous, one on ventral and one on dorsal side of stems, apices sometimes shallowly notched, 1.5 x 1.5 mm. *Flowers* solitary, occasionally two together, axillary. *Pedicel* 6—9 mm long. *Sepals* 5, ovate or obovate, some membranous margined, apex acute or obtuse, glabrous or glandular on dorsal surface, 4 x 3 mm. *Petals* 5, widely obovate or suborbicular, apex round, base with a short claw, dark yellow, banded with red or brown at the base of all petals forming an undulating band in the throat of the flower, or without any markings, 11–13 x 7–9 mm. *Nectar disc* fleshy, papillate, regularly 10-angled. *Stamens* 10; filaments terete, 5—7 mm long; staminal scales 10, simple, oblong or obovate, margins with long lacerations and bordered with short papillae on the upper half of the ventral surface, dorsal surface with less or no papillae, 3.0–4.0 x 1.5–2.0 mm; ± ½ the length of filament. *Ovary* ovoid, 5-lobed; style terete; stigma simple. *Fruit* a drooping, oblong, loculicidal capsule, 5-lobed, each lobe with a central ridge where splitting will occur, apex retuse, 9–10 x 8–9 mm. *Seed* oblong, 1or 2 per locule, 3.5–4.0 x 1.5–2.0 mm, dark brown with a white aril, testa smooth, glossy, producing yellowish, structured mucilage with long spiral inclusions of uniform width when wet (Figure 7.38.1).

Diagnostic characters and affinities

Z. porphyrocaule is recognized by its reddish-brown (hence the specific epithet), obviously zigzagging young stems with sessile, obovate leaflets, by its

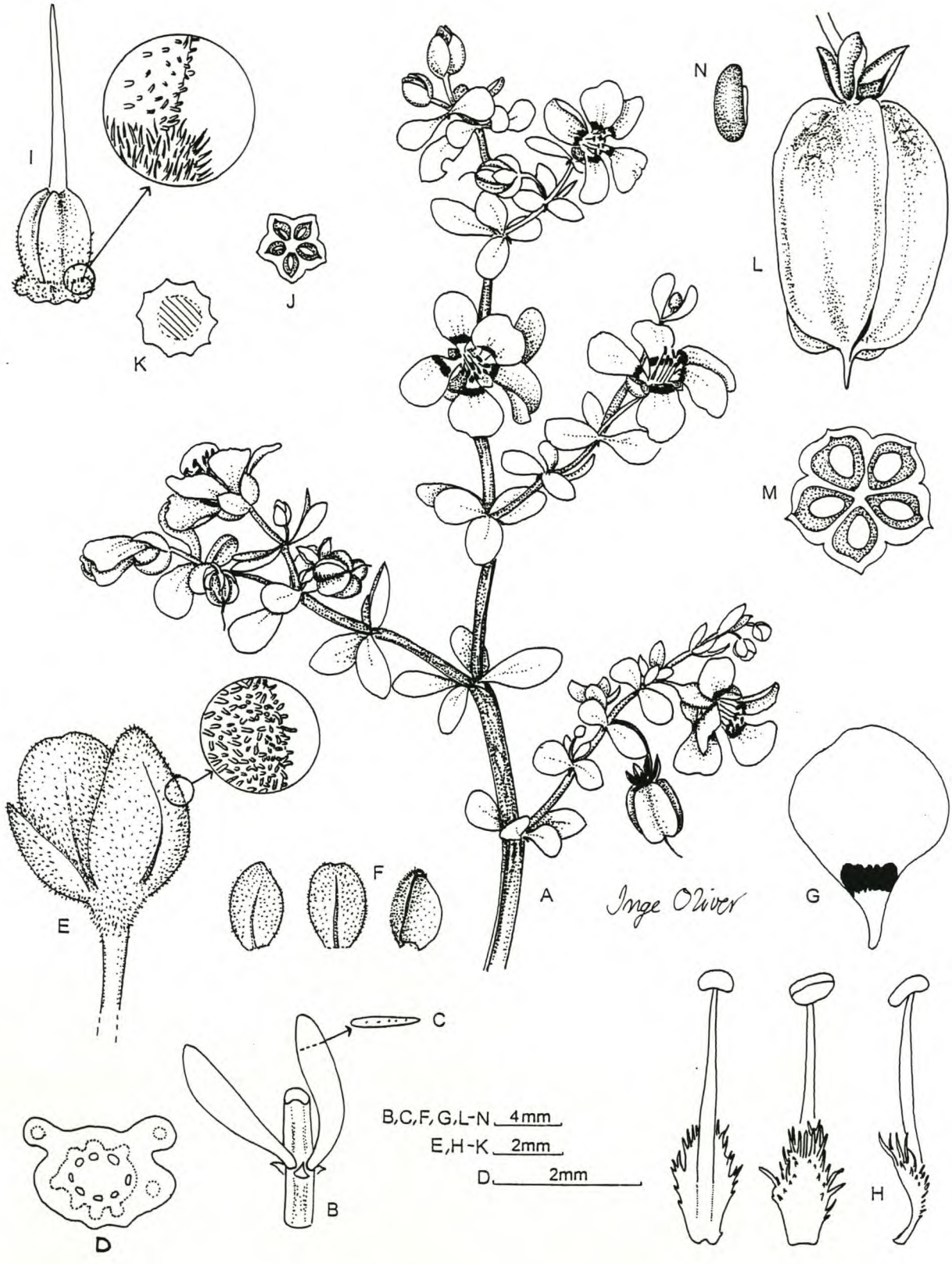


Figure 7.38.1. *Z. porphyrocaule, Van Zyl 4493.* A, flowering and fruiting branch, life-size; B, sessile leaflets; C, cross section of leaflet; D, cross section of young stem; E, glandular bud plus enlargement; F, glandular sepals; G, petal; H, dorsal-, ventral- and side-view of staminal scale; I, ovary on papillate nectar disc plus enlargement; J, cross section of ovary; K, cross section of nectar disc; L, mature fruit; M, cross section of mature fruit; N, seed with aril.

large, rounded habit, reaching a height and diameter of 1.5 m and by its oblong, 5-lobed fruits, each lobe with a prominent ridge where splitting will occur, 9–10 x 8–9 mm in size. Within § *Capensia*, in the group with sessile, (not terete or linear leaflets) to which it belongs, *Z. porphyrocaule* shows a close affinity with *Z. fulvum, Z. calcicola, Z. cuneifolium* and *Z. hirticaule* with regard to floral morphology. They all have staminal scales with a border of papillae as well as a filament to scale ratio of 2 : 1. The latter three species cannot be confused with *Z. porphyrocaule*, because of their different distribution areas. *Z. hirticaule* occurs in Namibia, *Z. cuneifolium* along the west coast and *Z. calcicola* along the south coast. The distribution of *Z. fulvum* overlaps with that of *Z. porphyrocaule*,but they are distinguished from each other by the obviously flexuous, reddish-brown young stems of *Z. porphyrocaule*. *Z. porphyrocaule* resembles *Z. swartbergense* in habit, both are large, woody shrubs, usually up to 1.5 m in height and diameter, but their staminal scales differ, those of *Z. swartbergense* lacking a border of papillae. They also have different distributions. *Z. porphyrocaule* occurs in the Worcester and Hexrivier valleys and in the Klein Karoo, and *Z. swartbergense* is restricted to the Swartberg range and the neighbouring Rooiberg and Gamkaberg. Table 7.9 summarizes the characters of the species in § *Capensia* with sessile, not terete or linear leaflets.

Distribution and ecology

Z. porphyrocaule is found in the Breederivier Valley around Worcester, in the Hexrivier valley, north of De Doorns, and towards the east in the Klein Karoo (Figure 7.38.2). It occurs in a vegetation classified as **Succulent Karoo Biome**: Little Succulent Karoo (Hoffman 1996), and **Fynbos Biome**: Central Mountain Renosterveld (Rebelo 1996). Soils of both these vegetation types are deep, fertile shale, derived from the Bokkeveld and Witteberg Groups. Both Biomes receive a low precipitation during winter, ranging from 150—300 mm for the Little Succulent Karoo and 250—400 mm per annum for the Central Mountain Renosterveld. Where a higher rainfall for the Succulent Karoo Biome occurs, the vegetation grades into the Mountain Renosterveld (Hoffman 1996).

Summers are hot and dry. These vegetation types include succulents, low trees and non-succulent shrubs like *Z. porphyrocaule,* whereas grasses are rare. The flowering period is from June to September. Mature fruits are found until October. Populations usually are small and consist of a few scattered individuals in or on the banks of damp dongas or dried out stream beds or in close proximity to rocky outcrops. Seedlings or juveniles are rare. *Z. porphyrocaule* is not palatable and is rarely grazed. However, due to the ever increasing development of the rich soils of its habitat and because of the small size and numbers of populations it seems likely that the distribution of this species will decline in future.

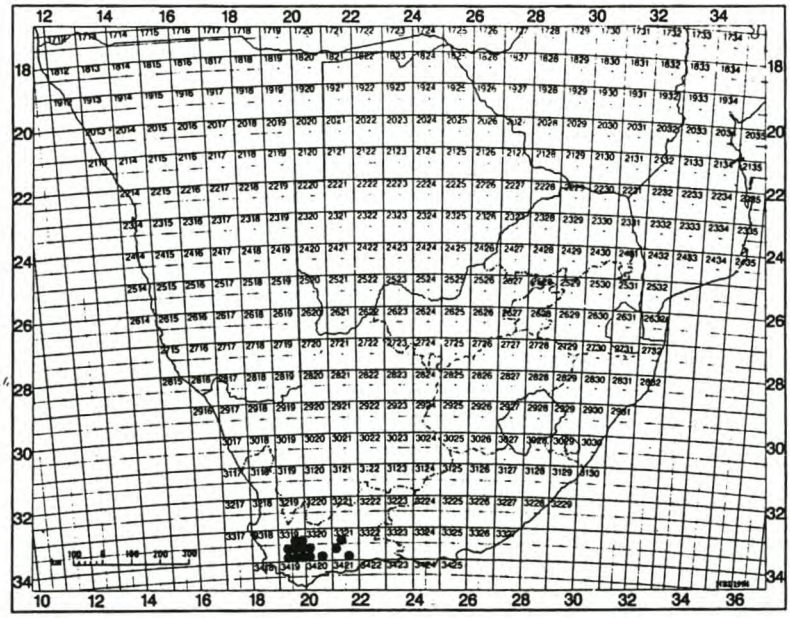


Figure 7.38.2. Geographical distribution of *Z. porphyrocaule*.

Specimens examined

–3319 (Worcester): Hexrivierpas, near summit (–BC), *Mauve & Oliver 178* (NBG), *Van Zyl 4244* (B, BOL, NBG, PRE); *Bolus 3052* (NBG), *Van Breda 202* (PRE); Near Matroosberg Stasie (–BD), *Levyns 6250* (BOL); Between Hugo and Kleinstraat Stasie, NE of De Doorns (–BD), *Van Zyl 3671* (NBG), *Van Zyl 3971* (BOL, NBG, S); Worcester Veldreservaat (–CB), *Olivier 18* (PRE); *Van Breda 19* (PRE); New extension to Worcester Karoo Garden (–CB), *Barker 8758* (NBG); Karoo Garden, Worcester (–CB), *Compton 19925* (NBG); Near Avondrust, between Villiersdorp and Worcester (–CD), *Van Zyl 4263* (NBG); Hammanshof, Worcester (–CD), *Bond 374* (NBG); Amandalia, NW of Robertson (–DA), *Van Zyl 4126, 4493* (NBG, PRE);

Mowershoogte, Worcester (–DA), *Van Rensburg 452* (NBG); Patryskloof, Worcester (–DA), *Hugo 2390* (NBG); Near Matroosberg Stasie (–DB), *Acocks 14549* (PRE); Madeba farm, 8 km W of Robertson (–DC), *Hilton-Taylor 1020* (NBG); Buitenstekloof, on Vinkrivier road (–DD), *Van Zyl 3674* (NBG); Vrolikheid, McGregor district (–DD), *Jooste 78, 129* (NBG); Near Robertson (–DD), *Morris 153* (NBG).

–3320 (Montagu): NE slopes of Wagenboomsbergen, Montagu (–CA), *Barker 8278* (NBG); E of Montagu (–CC), *Adamson s.n. (SAM 39061)*; 3 M E of Montagu (–CC), *Levyns 413* (NBG); Jakkalshoek, Montagu (–CC), *Van Breda s.n.* (B); 22 km W of Barrydale (–DC*), Thompson 21674* (NBG).

–3321 (Ladismith): S entrance to Seweweekspoort (–AD), *Van Zyl 3941* (BOL, NBG, PRE); Noukloof Nature Reserve, Little Karoo (–CA), *Laidler 75* (NBG); Vyeboomskraal, Little Karoo (–DC), *Laidler 533* (NBG).

7.39 Zygophyllum swartbergense *Van Zyl*, sp. nov., (§ *Capensia*), *Z. porphyrocauli* habitu magno plus quam 1.0 m altitudine afinis, sed foliolis ellipticus, squamis staminalibus breviter dentatis differt (non foliolis obovatis squamisque staminalibus marginibus superis longe laceratis, paginaque ventrali papillata, ut in *Z. porphyrocaule*). TYPE - Western Cape: Swartbergpas, between Eerste and Tweede Water, *Van Zyl 3622* (NBG, holo, B, S).

Erect, many-stemmed, woody shrub, densely leafy, reaching a height and diameter of 2 m. *Stems*: old stems leafless, bark grey and flaky; young stems green, flat on ventral side and with two lateral ridges, often with several more, less prominent, ridges on dorsal side. *Leaves* opposite, sessile, bifoliolate; rachis apex triangular, reflexed, becoming spinescent with age; leaflets articulate, green, leathery, elliptic, somewhat falcate, with midrib visible on adaxial side, apex acute, usually mucronate, margins slightly recurved, base narrowed, 12–20 x 3–6 mm; stipules triangular, often slightly notched at apex, one on ventral and one on dorsal side or stems, 0.5–1.0 x 0.5–1.0 mm. *Flowers* 1—2, axillary. *Pedicel* 5—8 mm long. *Sepals* 5, suborbicular or ovate, sometimes sparsely hairy, 4–5 x 4 mm. *Petals* 5, patent or reflexed during anthesis, widely obovate, apex obtuse, often emarginate, undulate, base with a short claw, deep yellow, marked at base in red, vaguely M-shaped figures, and usually topped with fainter red streaks or blotches or without any markings, 15 x 7–9 mm. *Nectar disc* fleshy, papillate, regularly 10-angled. *Stamens* 10;

filaments terete, 9—10 mm long; staminal scales 10, simple, oblong, margins with short lacerations, 3.0–3.5 x 1.0–1.5 mm; ± 1/3 the length of the filament. *Ovary* ovoid, 5-lobed; style terete; stigma simple. *Fruit* a drooping, oblong, 5-lobed, loculicidal capsule, each lobe with a sharp, central ridge where splitting will occur, 11–15 x 10–12 mm. *Seed* oblong, 1—4 per locule, 4.5 x 2.0 mm, dark brown with a white aril, testa smooth, glossy, producing brownish, structured mucilage with long spiral inclusions of a uniform width when wet (Figure 7.39.1).

Diagnostic characters and affinities

Z. swartbergense is recognized by its sessile, bifoliolate leaves with elliptic, falcate leaflets with a prominent adaxial midrib (Figure 7.39.2.C), by its large, erect habit, attaining a height and diameter of 2 m (Figure 7.39.2.A), and by its oblong, 5-lobed fruits, each lobe with a sharp, central ridge where splitting will occur. Within the group of § *Capensia* with sessile and flat leaflets to which it belongs, *Z. swartbergense* shows a close affinity to *Z. flexuosum* and *Z. fuscatum* with regard to floral morphology. They all have similar staminal scales which lack a border of papillae as well as a similar filament to scale ratio of 3 : 1. With regard to distribution areas they differ, with *Z. swartbergense* occurring inland on the Swartberg range and associated ranges and both *Z. flexuosum* and *Z. fuscatum* occurring along the south coast. *Z. swartbergense* resembles *Z. porphyrocaule*, both being large shrubs reaching heights of 1.5 m. They differ in floral and vegetative morphology though, with *Z. swartbergense* lacking the border of papillae on the staminal scales which are present on the scales of *Z. porphyrocaule*. The leaflets of *Z. swartbergense* are elliptic and falcate, with a midrib visible on the ventral side, and those of *Z. porphyrocaule* are obovate, without an obvious midrib. Table 7.9 summarizes the characters of the species in § *Capensia* with sessile, not terete or linear leaflets.

Distribution and ecology

Z. swartbergense is found on the northern and southern slopes of the Swartberg range and the neighbouring Rooi and Gamka Mountains (Figure

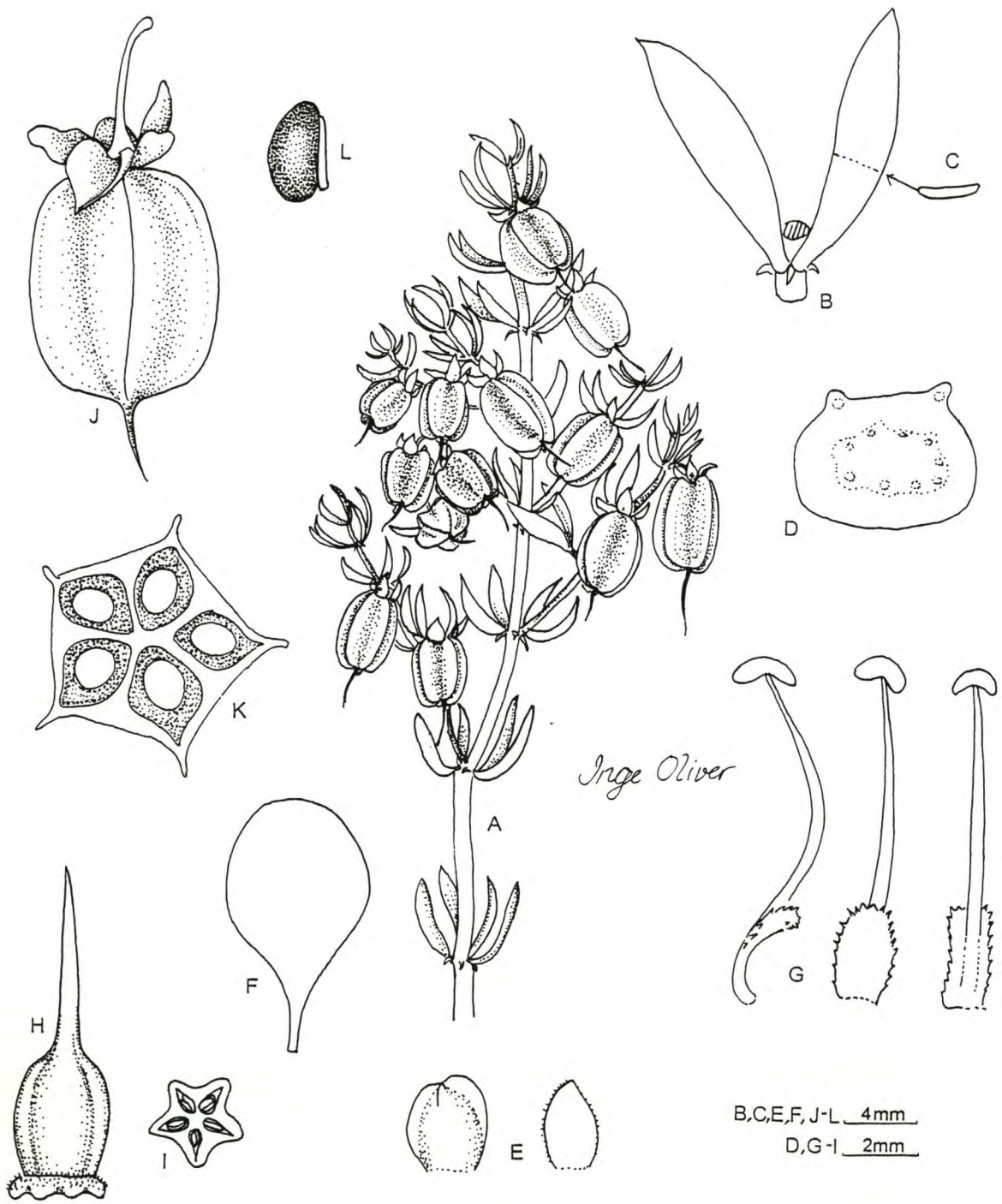


Figure 7.39.1. *Z. swartbergense*, *Van Zyl 4507*. A, fruiting branch, life-size; B, elliptic leaflets; C, cross section of a leaflet; D, cross section of young stem; E, sepals; F, petals; G, side-, ventral- and dorsal-view of staminal scale; H, ovary; I, cross section of ovary; J, mature fruit; K, cross section of mature fruit; J, seed with aril.

A

B

C

Figure 7.39.2. *Z. swartbergense, Van Zyl 3622.* A, habit in the Swartberg Pass; B, open flower with red markings at base of petals; C, twig with elliptic leaves and a yellow flower.

7.39.3). It occurs in a vegetation classified as **Fynbos Biome**: Central Mountain Renosterveld and Mountain Fynbos (Rebelo 1996). Central Mountain Renosterveld occurs on a substrate of shale and receives rain during winter, ranging from 250 to 400 mm per annum. The vegetation is described as low shrubland. Mountain Fynbos occurs mainly on sandstone and also receives rain during winter, ranging from 200 to 2000 mm per annum.
Populations are small, consisting of few, scattered shrubs, conspicuous by their size and abundance of flowers when in flower. No grazing damage occurs. Flowering period is from May to September.

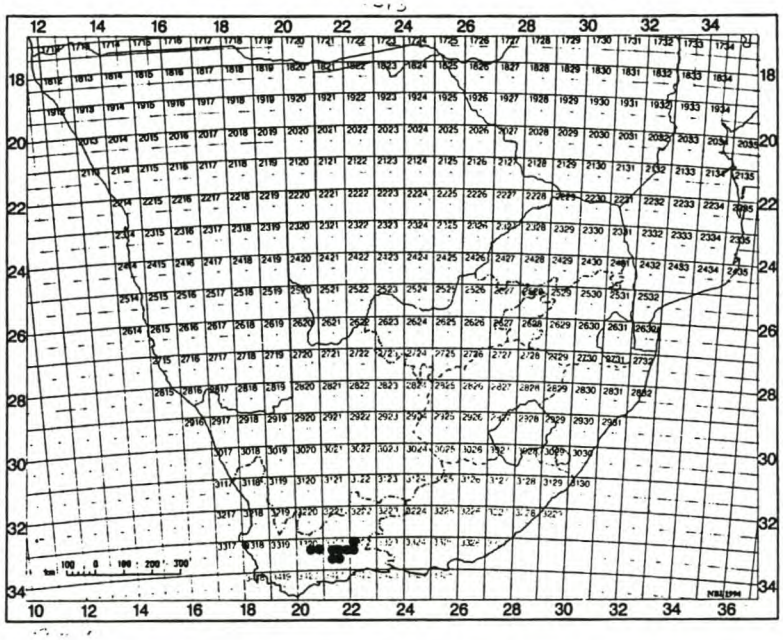


Figure 7.39.3. Geographical distribution of *Z. swartbergense*.

Specimens examined

–3320 (Montagu): Klein Spreeufontein mountains, 4.5 km WSW of farm house (–BC), *Oliver 10075* (NBG); Suikerdrifkloof, S of Laingsburg (–BD), *Van Zyl 3711* (NBG); Dry kloof between Ladismith and Anysberg (–BD), *Esterhuysen 17102* (BOL); Quartsite krantz, 30 m W of Ladismith (–BD), *Acocks 14566* (PRE).
–3321 (Ladismith): Seweweekspoort (–AD), *Phillips b1407* (SAM), *Van Wyk 361* (NBG, PRE); Bosluiskloof, between Prins Albert and Seweweekspoort (–AD/BC), *Lewis 4821* (PRE, SAM); Bosluiskloof, half way to the bottom (–AD/BC), *Van Zyl 3699* (NBG, PRE); N of Calitzdorp on gravel road to Matjiesvlei (–BC), *Van Zyl 3693* (B, BOL, NBG, S); N slopes of Gamkasberg (–BC), *Boshoff P164* (NBG); Gamkapoort Nature Reserve, highest ridge W of Dwyka river (–BC),

Laidler 671 NBG); Tierkloof, Gamka Reserve, near Calitzdorp (–BC), *Esterhuysen 33853* (BOL, S); Huisrivierpas (–BC/DA), *Hardy 313* (PRE); Groot Swartberg (–BD), *Marshall 235* (NBG); Rooiberg (–CB), *Marshall 88* (NBG); Top of Roodebergpas (–DA), *Lewis 4822* (PRE, SAM). **–3322** (Oushoorn): Lower, W facing rocks near caravan park, Prins Albert (–AA), *Wisura 3389* (NBG); Foothills of Swartberg, Prins Albert (–AA/AC), *Acocks 14323* (PRE); Swartbergpas, near Prins Albert (–AC), *Tugwell s.n.* (BOL 13421); N side of Swartbergpas (–AC), *Wall s.n.* (S); Swartbergpas, between Eerste and Tweede Water (–AC), *Van Zyl 3622* (NBG, PRE); Near Eerste Water, N side of Swartbergpas (–AC), *Van Zyl 4507* (B, BOL, NBG, PRE, S, WIND); Lower N slopes of Simonsberg, Prins Albert (–AC), *Bond 1700* (NBG); Between Prins Albert and Cango caves (–AC), *Krige s.n.* (BOL 13421).

7.40 Zygophyllum fuscatum *Van Zyl* in Van Zyl & Marais, Bothalia 27, 2 : 129 (1997). TYPE - Western Cape: Coastal dunes between Kleinbaai and Danger Point, *Van Zyl 4293* (NBG, holo, K, B, PRE).

Erect, many-stemmed, woody shrub, reaching a height of 1.0 m and a diameter of 1,5 m. *Stems:* old stems nude, dark grey, bark rough; young stems green, densely leafy, flat on ventral side, with lateral ridges each ending in an acute, distinct, distal lobe. *Leaves* opposite, subpetiolate, bifoliolate, secund; rachis apex subulate, 0.5 x 0.3 mm; petiole adaxially grooved, 0.3—0.5 mm long; leaflets articulate, khaki or yellowish-green, when dry dark brown or nearly black, elliptic or obovate, apex rounded or acute, mucronate, base narrowed, midrib visible on both surfaces, 12–16 x 2–5 mm; stipules semi-circular, caducous, one on ventral and one on dorsal side of stems, with a notched apex, 0.5–1.5 x 1–2 mm. *Flowers* solitary or rarely two together, axillary. *Pedicel* 1—2 mm long. *Sepals* 5, ovate or elliptic, acute, 6–8 x 3–4 mm. *Petals* 5, subrotund or obovate, apex rounded or acute, base with a short claw, deep yellow, variously marked at the base with red or brown, or without markings, 10–14 x 5–7 mm. *Nectar disc* fleshy, papillate, regularly 10-angled. *Stamens* 10; filaments terete, 5.5—8.0 mm long; scales 10, simple, oblong, margins lacerate, 2.0–3.0 x 1.0–1.5 mm, ± 1/3 the length of the filament. *Ovary* oblong, 5–lobed, style terete, stigma simple. *Fruit* a drooping, oblong, 5–lobed, loculicidal capsule, each lobe with a sharp, central ridge where splitting will occur, 12–14 x 11–12 mm. *Seed* oblong, 1—3 per locule, dark brown with a

white aril, 4 x 2 mm, testa smooth, glossy, producing structured mucilage with long, spiral inclusions of a uniform width when wet (Figure 7.40.1).

Diagnostic characters

Z. fuscatum is distinguished by its densely leafy, secund branches (Figure 7.40.2) with leaflets that become dark brown or nearly black when dry (hence the specific epithet), by its very short pedicels of 1—2 mm in length and by its young stems with a flat ventral side and with its lateral ridges ending in distinct, acute, distal lobes (Figure 7.40.1.D). These distal lobes are unique for the southern African species of *Zygophyllum*. *Z. fuscatum* is allied to the species in § *Capensia* with sessile leaves and flat laminas and which have a similar floral morphology, like *Z. flexuosum* and *Z. swartbergense*. These three species have similar staminal scales with lacerated margins which are without additional papillae on the surfaces and they have a filament to scale ratio of 3 : 1. *Z. swartbergense,* restricted to the Swartberg and adjacent mountain ranges, occupies a different distribution area to *Z. fuscatum*, but the distribution of the latter overlaps with that of *Z. flexuosum*. Both *Z. fuscatum* and *Z. flexuosum* are restricted to narrow strips along the southern and western coastline. They are distinguished by their different fruits, those of *Z. flexuosum* are succulent when fresh and become 5-angled when dry and those of *Z. fuscatum* are distinctly 5-angled. Table 7.9 summarizes the characters of the species in § *Capensia* with sessile, not terete or linear leaflets.

Distribution and ecology

Z. fuscatum is found in a narrow strip along the coast from Bettiesbaai in the west to De Hoop Nature Reserve in the east, usually in close proximity to the sea and at low altitudes of 1 to 300 m (Figure 7.40.3). It occurs in a vegetation classified as **Fynbos Biome**: Limestone Fynbos (Rebelo 1996), which is restricted to calcareous, neutral to alkaline, shallow sands overlying limestone and associated calcretes of the Bredasdorp Formation. The area receives rain during the autumn, winter and spring, rainging from 350—600 mm per year. *Z.*

Figure 7.40.1. *Z. fuscatum, Van Zyl 4293.* A, flowering branch; B, fruiting branch; C, pair of leaflets with rachis apex; D, leaflet arrangement, lateral ridges ending in distinct distal lobes; E, cross section of young stem; F, sepal; G, petal; H, cross section of fruit; I, dorsal-view of staminal scale; J, ovary on papillate nectar disc; K, cross section of ovary.

Figure 7.40.2. *Z. fuscatum, Van Zyl 4294*, habit near Die Kelders.

fuscatum thrives in direct sunlight and is a pioneer in disturbed areas along roadsides. Populations consist of many scattered individuals including seedlings and young plants. Grazing damage does occur, but is never excessive. *Z. fuscatum* is common where found and the species seems not to be threatened at present. However, its coastal habitat, is under ever more pressure for development, which makes its future uncertain. Part of its habitat is protected in the De Hoop Nature Reserve. Flowering occurs from May to August and fruiting shortly after.

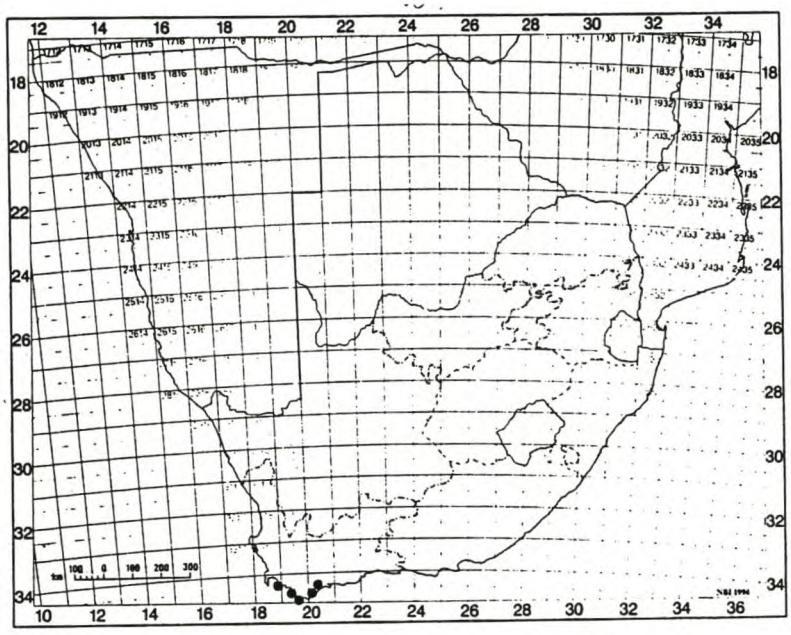


Figure 7.40.3. Geographical distribution of *Z. fuscatum*.

Specimens examined

–3418 (Simonstown): Holbaai Peninsula, E of Hangklip (–BD), *Rourke 423* (NBG); E of Blesberg, Hangklip (–BD), *Boucher 684* (NBG); Bettiesbaai (–BD), *Hall 1738* (NBG).
–3419 (Caledon): Danger Point, Caledon (–CB), *Lewis 4025* (SAM); Danger Point, Caledon (–CB), *Martin 338* (NBG); Near Die Kelders (–CB), V*an Zyl 4294* (NBG); Coastal dunes, W of Kleinbaai (–CB), *Van Zyl 4292* (NBG); Coastal dunes between Kleinbaai and Danger Point (–CB), *Van Zyl 4293* (NBG); Coastal fynbos at Buffelsjag, Quoin Point (–DC), *Van der Zeyde 54/83* (NBG); Near the mouth of Ratelrivier (–DC), *O'Callagan, Van Wyk & Fellingham 471* (NBG); Near Quoin Point, Buffelsjag (–DC), *Van Zyl 4290* (NBG).
–3420 (Bredasdorp): Dronkvlei flats, De Hoop Nature Reserve (–AD), *Burgers 1854* (NBG); Near Arniston (–CA), *Marsh 1452* (PRE, NBG); Coastal Dunes near Bredasdorp (–CA), *Van Breda 814* (PRE).

7.41 Zygophyllum flexuosum *Eckl. & Zeyh.* Enumeratio plantarum.....1 : 97 (1835); Sond.: 359 (1860); Huysst.: 70 (1937); Adamson & Salter: 534 (1950); Bond & Goldblatt: 437 (1984). TYPE - Western Cape: In collibus vicinis urbi Caledon (altit II). *Ecklon & Zeyher 768* (S!, lecto, designated here, KIEL!).

Zygophyllum commelini *Eckl. & Zeyh.*: 97 (1835). In dunis arenosis prope "Rietvalley et Saldanhabay" (Cap). Nov. *Ecklon & Zeyher 765* (S, lecto!, designated here, C!, SAM!)

Zygophyllum flexuosum *Eckl. & Zeyh.* **var. ß** Sond.: 359 (1860). This taxon lacks an epithet, is not validly published and thus without a type. Kalkbay, *Pappe s.n.* (S X 3, TCD).

Misidentification: *Zygophyllum retrofractum* sensu Jacq.: 354 (1798).

Erect or spreading, many-stemmed, densely leafy shrub or shrublet, reaching a height of 0.2— 0.8 m and a diameter of 1.0 m. *Stems*: old stems nude, bark rough, gray, cracked; younger branches flexuose, smooth, leafy, flat on ventral side and with prominent, lateral ridges. *Leaves* opposite, sessile, bifoliolate; rachis apex triangular, brownish, reflexed, stiff, base spinescent, 1.0 x 0.5 mm; leaflets articulate, green, obovate, becoming succulent with age, apex rounded, mucronate, lamina flat or with recurved margins, base obtuse or cuneate, 11–17 x 3–7 mm; stipules triangular, brown, stiff, reflexed, base spinescent, one on ventral and one on dorsal side of stems with apex often notched, 1.0–1.5 x 0.5–1.0 mm. *Flowers* 1—2, axillary. *Pedicel* 10—14 mm long. *Sepals* 5, ovate or obovate, apex acute or rounded, some with membranous, sometimes fimbriate margins, 4–7 x 3–4 mm. *Petals* 5, often reflexed, obovate or widely obovate, apex obtuse, often emarginate, base with a short claw, rich yellow, variously marked at base with red or reddish-brown, vaguely T-shaped blotches, 11–18 x 4–9 mm. *Nectar disc* fleshy, papillate, regularly 10-angled. *Stamens* 10; filaments terete, 7—9 mm long; staminal scales 10, simple, oblong, apex obtuse, margins finely lacerate, 2–3 x 1.5–2.0 mm, ± 1/3 the length of the filament. *Ovary* spherical, vaguely 5-lobed; style terete; stigma simple. *Fruit* a drooping, subspheroid, loculicidal capsule, base and apex

obtuse, always wider than long; when fresh succulent, juicy, vaguely lobed and with 5 sutures faintly visible; when dry 5-angled and wrinkled, 8–9 x 9–12 mm. *Seed* subspheroid, embedded in an extremely sticky substance, 1 per locule, 3.0–3.5 x 2.5–3.0 mm, dark brown with a white aril, testa smooth, glossy, producing copious, brown, structured mucilage with long spiral inclusions of a uniform width when wet (Figure 7.41.1).

Diagnostic characters and affinities

Z. flexuosum is distinguished by its flexuose stems which are flat on the ventral side with lateral ridges, by its sessile, obovate leaflets (Figure 7.41.2.A,C) and by its fresh fruits that are wider than long, subspheroid, succulent, vaguely 5-lobed and with 5 sutures faintly visible (Figure 7.41.2.B) and which become 5-angled with a slightly wrinkled exocarp when dry. The single seeded locules of *Z. flexuosum* are filled with an extremely sticky substance which cover the seed. *Z. flexuosum* is allied to the species in § *Capensia* with sessile leaves and flat laminas and with regard to floral morphology it is closest to *Z. fuscatum* and *Z. swartbergense* which have similar staminal scales without a border of papillae. *Z. swartbergense* and *Z. fuscatum* have fruits which are always longer than wide and prominently 5-lobed and ridged in contrast to those of *Z. flexuosum* which are wider than long and at most 5-angled when dry. Table 7.9 summarizes the characters of the species in § *Capensia* with sessile, not terete or linear leaflets. The specific epithet refers to its prominently zigzagging stems.

Distribution and ecology

Z. flexuosum is found in a narrow strip along the South African coastline from Velddrift on the west coast to as far east as the Goukamma Nature Reserve at Buffelsbaai (Figure 7.41.3). It occurs in a vegetation classified as **Thicket Biome**: Dune Thicket (Lubke 1996) which consists of dense thickets on dunes close to the sea and at low altitudes, usually less than 30 m above sea level. In the western part of its range, rainfall occurs during winter and towards its

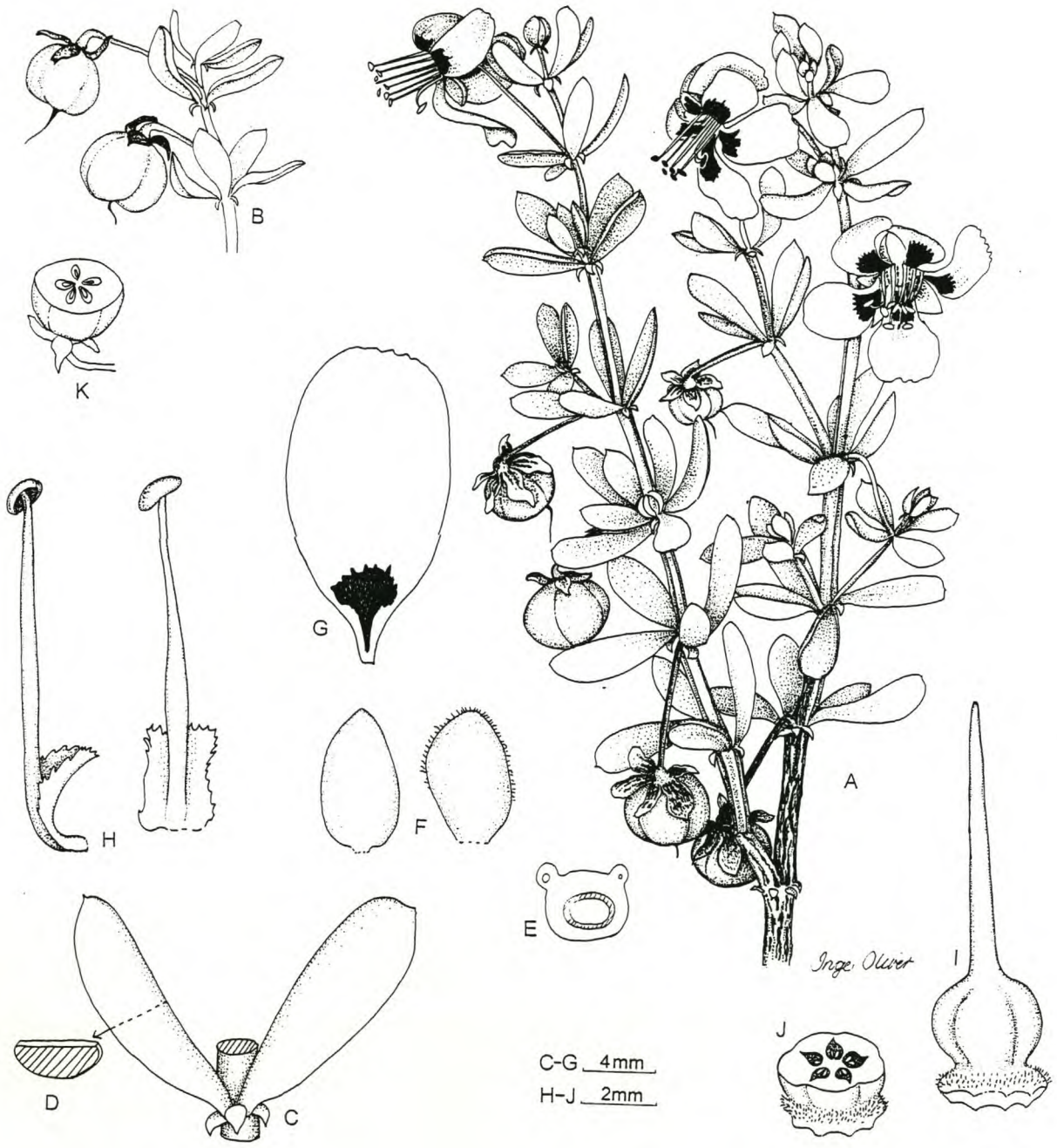


Figure 7.41.1. *Z. flexuosum, Van Zyl 4195.* A, flowering and fruiting branch, life-size; B, fruiting branchlet, life-size; C, leaflets with rachis apex and stipules visble; D, cross section of leaflet; E, cross section of young stem; F, sepals; G, petal; H, side- and dorsal-view of staminal scale; I, ovary on papillate nectar disc; J, cross section of ovary; K, cross section of mature, succulent fruit.

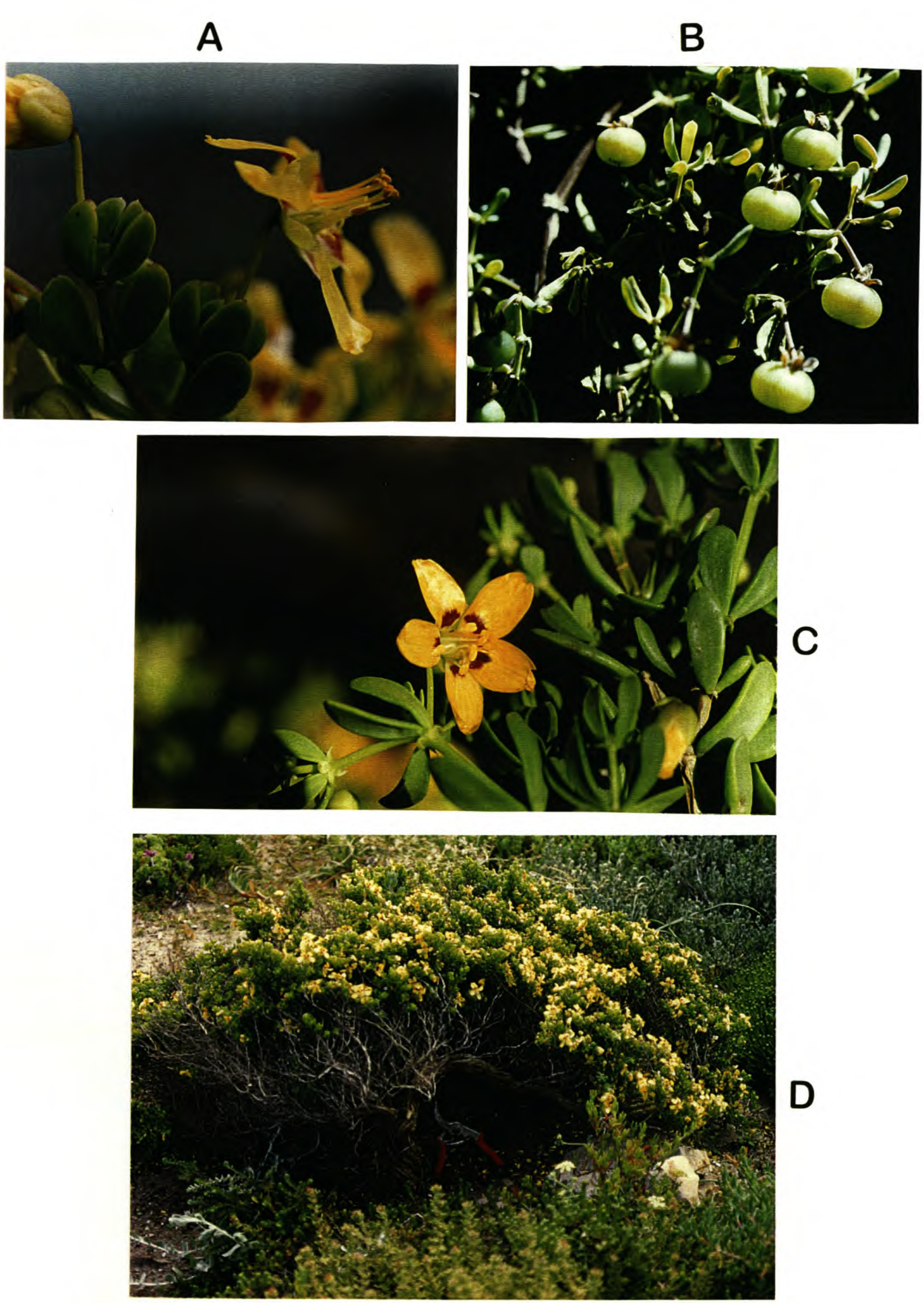


Figure 7.41.2. *Z. flexuosum*, A,C,D, *Van Zyl 3968*; B, *Van Zyl 4291*. A, twig with flowers and obovate leaflets; B, drooping, wider than long, succulent, fresh fruits; C, twig displaying reflexed stipules as well as yellow petals with red markings; D, habit at Maclear Beach, Cape of Good Hope Nature Reserve.

eastern boundary, throughout the year and ranges from 900—1500 mm per year. Summers are hot and usually dry towards the western part of the distribution area. Substrates are deep, regic dune sands with little humus build up and the vegetation includes trees, shrubs, climbers and a few herbs. Populations are never large and the occurrence of this species is sometimes described as rare. It usually consists of occasional, scattered individuals, including seedlings and young plants. Flowering occurs from June to October. In the Blouberg - Melkbos area, the leaflets of *Z. flexuosum* are markedly wider than the norm. *Z. flexuosum* is palatable and extreme grazing damage to it was seen in the De Hoop Nature Reserve. Because of its specialized habitat, stretched out along the coastline, which is ever more under development pressure, this species could face a drastic shrinkage of its distribution in future. Common names: maerbossie, spek(brood).

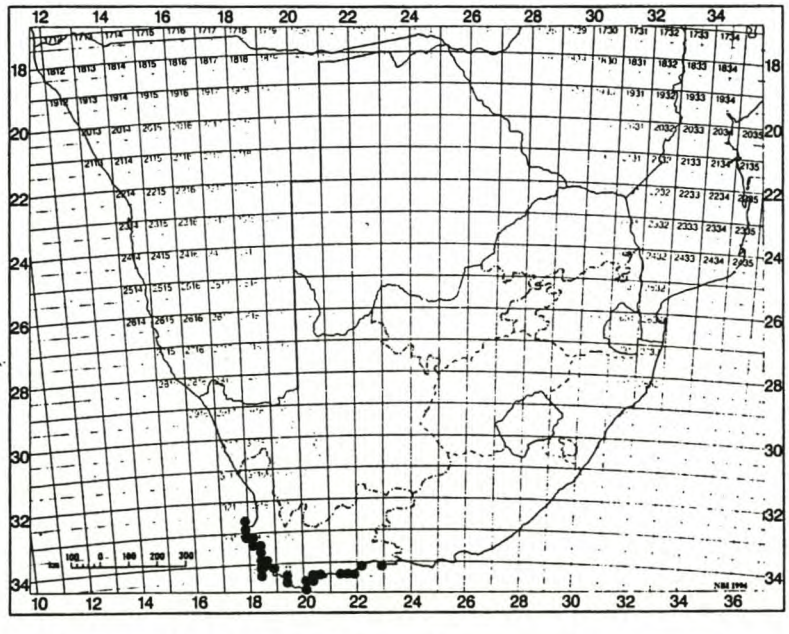


Figure 7.41.3. Geographical distribution of *Z. flexuosum*.

Specimens examined

–3217 (Vredenburg): Coastal dune at Shell Bay, near Veldrif (–DB), *Thompson 816* (NBG); Between Paternoster and Cape Columbine (–DD), *Wisura 376* (NBG); Dunes at Tietiesbaai (–DD), *Van Zyl 4194* (NBG).

–3317 (Saldanha): Saldanha (–BB), *Marloth 5205* (PRE); Danger Bay, Saldanha (–BB), *Leighton 1734* (BOL); In sand at Hoedtjies Bay, Saldanha (–BB), *Bolus 12625* (BOL); *Barker 9686* (NBG).

–3318 (Cape Town): Rietvalley & Saldanha Bay, *Ecklon & Zeyher 765* (C, S, SAM). Geelbek (–AA), *Barker 4613* (NBG); *Bösenberg & Rutherford 93* (NBG); Dune sand at Schrywershoek, Langebaan Peninsula (–AA), *Boucher 2932* (NBG, PRE); *Boucher 2787* (NBG); Langebaan (–AA), *Leipoldt s.n.* (STE 18255 in NBG); Sand on limestone at Churchaven (–AA), *Van Zyl 3607* (NBG); Flats at Langfontein, N of Betjieskop (–AA), *Boucher 3800* (NBG, PRE); Near Preekstoel, Langebaan (–AA), *Van Zyl 3608* (NBG); At Blombos, on gravel road between Yzerfontein and Langebaan (–AC), *Van Zyl 3606* (NBG, PRE); Yzerfontein (–AC), *Marloth 4042* (PRE); *Acocks 14512* (PRE); *Pillans s.n.* (BOL 49278); *Johnson 169* (NBG); *Van Zyl 3604* (BOL, NBG, PRE); Darling (–AD), *Eames s.n.* (BOL 49305); New road extensions to Melkbos from Blouberg (–CB), *Barker 9068* (NBG); Sand dunes at Blouberg (–CB), *Barker 9231* (NBG); *Compton 14636* (NBG); *Davis s.n.* (SAM 63612); *Leighton 3* (BOL); *Levyns 11525* (BOL); Sandy coast at Melkbos (–CB), *Pillans 8838* (BOL); *Morris 132* (NBG); In sand at Bokbaai (–CB), *Van Niekerk 674* (BOL); Dunes at Philadelphia (–CB), *Wasserfall 210* (NBG); Slopes N of Kirstenbosch, above road (–CD), *Gillett 102 B* (NBG); Dry sand at Klein Zoarvlei, Paarden Eiland (–CD), *Linder 2165* (BOL); Holbaai (–CD), *Meyer 7062 A* (PRE); Milnerton Golf Links (–CD), *Salter 7450* (BOL); Dunes, on road between Mowbray and Faure (CD), *Esterhuysen 23146* (BOL); Sandy flats E of Mowbray (–CD), *Pillans 1907* (BOL); N of Golf Course at Dieprivier (–CD), *O'Callaghan 1287* (NBG); Flats 5 M SW of Blue Downs Station, Blackheath (–DC), *Oliver 4044* (NBG); Dune edge at Cape Flats Nature Reserve, Univ. W. Cape (–DC), *Low 636* (NBG).

–3418 (Simonstown): Between Lakeside and Retreat (–AB), *Bolus 15819* (BOL, PRE); Rondevlei (–AB), *Compton 24357* (NBG); In sand at Kalk Bay (–AB), *Zeyher ?1191?* (SAM 14503); Red Hill, Cape Peninsula (–AC), *Salter 7428* (BOL); Sea cliffs at Smitswinkelbaai (–AD), *Van Zyl 3966* (BOL, NBG, PRE); Littoral dune at Kromrivier, Cape of Good Hope Nature Reserve (–AD), *Taylor 7121* (NBG); Flats near sea at Buffelsbaai, Cape of Good Hope Nature Reserve (–AD), *Leighton 30* (BOL); Sandy flats near sea at Maclear Beach (–AD), *Van Zyl 3968* (NBG, PRE); Flats near Tygerberg (–BA), *Smuts s.n.* (STE 31752 in NBG); Sandy soil near Faure (–BA), *Van Rensburg 451* (NBG, PRE); Sandy flats near Phillipi (–BA), *Museum Staff s.n.* (SAM 59101); Between Strandfontein and Muizenberg (–BA), *Esterhuysen 35506a* (BOL); Strandfontein (–BA), *Compton 13704* (NBG); Coastal dunes between Eersterivier and Swartklip (–BA), *Pillans 9212* (BOL); Sand dunes on Cape flats (–BA), *Joubert s.n.* (STE 26399 in NBG); Macassar dunes (–BA/BB), *De Bruyn 2* (NBG); Dunes S of Kramat, Faure (–BB), *Jordaan 656* (NBG); Sand dunes at Strand (–BB), *Parker 3583* (BOL, NBG); Sandy road towards Macassar beach (–BB), *Van Jaarsveld 3525* (PRE).

–3419 (Caledon): On road between Stanford and Gansbaai (–AD/CB), *Gillett 4270* (BOL, PRE); Hills near Caledon-(this must be the S side of Kleinriviersberge) (–AD), *Ecklon & Zeyher 768* (SAM); Fixed dunes W of Kleinbaai, near Franskraal (–CB), *Van Zyl 4291* (NBG); 8 M inland

–3419 (Caledon): On road between Stanford and Gansbaai (–AD/CB), *Gillett 4270* (BOL, PRE); Hills near Caledon-(this must be the S side of Kleinriviersberge) (–AD), Ecklon & Zeyher 768 (SAM); Fixed dunes W of Kleinbaai, near Franskraal (–CB), *Van Zyl 4291* (NBG); 8 M inland from Gansbaai and Danger Point (–CB), *Stokoe s.n.* (SAM 59096); Danger Point (–CB), *Van Zyl 4247* (NBG, PRE); Sandy soil on Langbosch, Gansbaai (–CB), *Walters 406* (NBG); Strandskloof, Bredasdorp (–CB), *Compton 14748* (NBG).

–3420 (Bredasdorp): Stabilized dunes on road to Koppie Alleen, De Hoop Nature Reserve (–AD), *Van der Merwe 143* (NBG, PRE); Die Mond, in De Hoop Nature Reserve (–AD), *Van Zyl 4286* (NBG); White sand dunes at Koppies, De Hoop Nature Reserve (–AD), *Van Der Merwe 1184* (PRE); 0.3 km from coast on Potberg, De Hoop Nature Reserve (–BC), *Burgers 1014* (NBG); Stable dunes 0.5 M from Arniston to Bredasdorp (–CA), *Marsh 918* (NBG); Frikkiesbaai, Bredasdorp (–CA), *Compton 18193* (NBG); *Leighton 1915* (BOL); 3 M NE of Skipskop, Bredasdorp (–CB), *Gentry & Barclay 18864* (PRE); Limestone outcrops on Buffelsfontein, De Hoop Nature Reserve (–CB), *Van Wyk 1827* (NBG); *Fellingham 765* (NBG, PRE); Sandy slopes at base of hills at Cape Agulhas (–CC), *Esterhuysen 36103* (PRE).

–3421 (Riversdale): Plot in Panorama Circle 16, Stilbaai (–AD), *Bohnen 3862* (NBG); Sandy area in Stilbaai (–AD), *Ryecroft 3071* (NBG); *Muir 3127* (BOL, PRE); Melkhoutfontein, Riversdale (–AD), *Galpin 3802* (PRE); Disturbed coastal thicket at Mias-se-Huis, Ystervarkpunt (–BC), *Willemse 567* (NBG); Dunes ± 0.3 km from Vermaaklikheid on road to Puntjie (–BD), *Van Wyk, Fellingham & O'Callaghan 428* (NBG, PRE).

–3422 (Mosselbaai): Dunes on E side of Blinderivier estuary, Mosselbaai (–AA), *Van Wyk, Fellingham & O'Callaghan 257* (NBG); River bank 1 km from mouth of Goukammarivier (–BB), *Van Wyk, Fellingham & O'Callaghan 99* (NBG); Circular trail on W side of river in Goukamma Nature Reserve (–BB), *Van Zyl 3630* (BOL, NBG, PRE).

Unknown or no precise localities: On dunes at Brandfontein, Bredasdorp, *Smith 3124* (PRE); Anon. s.n. (SAM 30026); Planiti Capensi, Zeyher 770 (GRA);

Key to the species in § *Capensia* with petiolate leaves (including two species with sessile or petiolate leaves):

1a Fruits not ridged or winged.....2

1b Fruits ridged or winged.....4

2a Young stems prominently white, erect or rounded shrubs.....3

2b Stems prostrate or scrambling, thin and flexible, reaching a length of several meters, fruits oblong or spheroid, not ridged but with visible sutures.....*Z. maritimum*

3a Staminal scales bordered with papillae ....*Z. cretaceum*

3b Staminal scales without a border of papillae .....*Z. leucocladum*

4a Fruits winged.....5

4b Fruits ridged.....7

5a Erect, many-stemmed, woody shrub with hollow stems, fruits large, 25–43 x 15–20 mm in size, prismatic, 5-winged.....*Z. macrocarpon*

5b Stems not hollow, fruits winged, not exceeding 26 mm in length 6

6a Decumbent shrublet with oblong, 5-winged fruits, 12–26 x 9–14 mm in size, usually burgundy coloured.....*Z. debile*

6b Erect shrub with subspheroid, 5-winged fruits, 6–7 x 6–8 mm in size, usually green .....*Z. lichtensteinianum*

7a Stems striate when fresh and usually hairy.....8

7b Stems not striate or hairy.....11

8a Petals white- and red-veined, staminal scales bordered with dense, curly papillae, filament to scale ratio 5 : 1.....*Z. leptopetalum*

8b Petals yellow, filament to scale ratio 3 : 1 or less.....9

9a Leaflets trifoliolate.....*Z. schreiberanum*

9b Leaflets bifoliolate.....10

10a Staminal scales bordered with papillae, filament to scale ratio 2 : 1.....*Z. maculatum*

10b Staminal scales without a border of papillae, filament to scale ratio 3 : 1.....*Z. pubescens*

11a Stems prominently white-pustulate, spines presents.....*Z. incrustatum*

11b Stems not white-pustulate, spines absent.....*Z. foetidum*

7.42 Zygophyllum lichtensteinianum *Cham.* in Linnaea 5 : 47 (1830); Don: 771 (1831); Eckl. & Zeyh.: 96 (1835); Sond.: 363 (1860); Huysst.: 75 (1937); Bond & Goldblatt: 437 (1984). TYPE: without locality, (B-Licht †); *Willd 8094* (fol. 1 B-W!, lecto, designated here).

Zygophyllum thunbergianum *Eckl & Zeyh.*: 97 (1835); Sond.: 363 (1860). TYPE: Inter frutices loci deserti "Karro" ad fluvium "Gauritzrivier" (Swellendam), *Ecklon & Zeyher 763* (S!, lecto, designated here, C! SAM!).

Zygophyllum gilfillani *N.E.Br.*: 100 (1906); Huysst.: 76 (1937); Le Roux et al.: 136 (1994). TYPE - Eastern Cape: Conway farm, Middelburg district, *Gilfillan in Herb. Galpin 5512* (BOL!, holo).

Zygophyllum arenicolum Schltr. nom. nud. based on *Schlechter 11402*, collected at I'us (Z!).

Rounded, many-stemmed shrub, branched from the base, reaching a height and diameter of 1 m but usually recorded as 0.4–0.5 m in height due to heavy grazing. *Stems*: old stems grey, flexible, bark rough; young stems smooth, greenish-grey with a flat ventral area and poorly developed lateral ridges. *Leaves* opposite, petiolate, bifoliolate; rachis apex widely triangular, 0.3 x 0.6 mm, erect or patent; petiole flat, adaxially grooved, 3—10 mm long; leaflets glaucous or green, usually articulate, asymmetrical, obovate, 8–17 x 5–6 mm, apex obtuse, base oblique; stipules membranous, widely triangular, one on ventral side and one on dorsal side of stems, 0.5 x 1.0 mm, soon distorted by secondary growth in stem, reflexed, caducous. *Flowers* solitary, axillary. *Pedicel* 11—14 mm long. *Sepals* 5, ovate or obovate, some membranous margined, sparsely covered with short, straight hairs, persistent, becoming reflexed at the fruiting stage, 2.0–4.0 x 2.0–2.5 mm. *Petals* 5, suborbicular or widely obovate, apex rounded, emarginate, base with a short claw, pale yellow with reddish-brown, narrowly transverse, rhombic markings at the base, 8–11 x 3–6 mm. *Nectar disc* fleshy, papillate, 10-angled. *Stamens* 10; filaments terete, 6—7 mm long; staminal scales 10, simple, obovate or oblong, nearly transparent, apex rounded, margins lacerate, without a border of papillae, 2–3 x 0.8–1.5 mm, ± 1/3 the length of the filament. *Ovary* spheroid, 5-winged; style terete; stigma simple. *Fruit* a subspheroid, 5-winged, loculicidal capsule, 6–7 x 6–8 mm in size, with reticulate-veined, 2—3 mm wide wings, apex and base usually retuse. *Seed* oblong, 1—3 per locule, 3 x 1.5–2.0 mm, dark brown with a white aril, testa

smooth, glossy, producing structured, brown mucilage with long, spiral inclusions of a uniform width when wet (Figure 7.42.1).

Diagnostic characters and affinities

Z. lichtensteinianum is distinguished by its petiolate leaves with flat petioles and asymmetrical obovate leaflets and by its small, 5-winged fruits, 6–7 x 6–8 mm in size with wings 2—3 mm wide. With regard to leaf morphology it resembles *Z. macrocarpon, Z. foetidum, Z. cretaceum* and *Z. leptopetalum*, all with petiolate, bifoliolate leaves with asymmetrical obovate leaflets. The leaflets of *Z. lichtensteinianum* are the smallest (8–17 x 5–6 mm in size), and those of *Z. macrocarpon* the largest (35–50 x 30–45 mm in size). The staminal scales of *Z. lichtensteinianum* are without a border of papillae on its surface and in this respect it shows an affinity to other species in § *Capensia* with petiolate leaves like *Z. incrustatum, Z. debile* and *Z. maritimum* which all have similar staminal scales. They differ with regard to their vegetative morphology, *Z. debile* is a small shrublet with glaucous leaves and Z. *maritimum* has prostrate or scrambling branches. The specific epitheton *lichtensteinianum* commemorates M.H.C. Lichtenstein. Table 7.10 summarizes the characters of the species in § *Capensia* with petiolate leaflets.

Distribution and ecology

Z. lichtensteinianum is widespread in the interior of South Africa. It occurs from Kimberley in the north to the Groot and Klein Karoo in the south and from Calvinia in the west to Britstown in the east (Figure 7.42.2). Because *Z. lichtensteinianum* is so widespread it occurs in different Biomes, classified as **Thicket Biome**: Xeric Succlent Thicket and Spekboom Sukkulent Thicket (Lubke 1996); **Savanna Biome**: Kalahari Plains Thorn Bushveld and Kimberley Thorn Bushveld (Van Rooyen & Bredenkamp 1996); **Nama Karoo Biome**: Bushmanland Nama Karoo, Upper Nama Karoo, Orange River Nama Karoo, Eastern Mixed Nama Karoo, Great Nama Karoo and Central Lower Nama Karoo (Hoffman 1996); **Succulent Karoo Biome**: Upland Succulent Karoo and Little Succulent Karoo (Hoffman 1996). Towards the west the distribution area receives winter rainfall of 150—300 mm per year, whereas

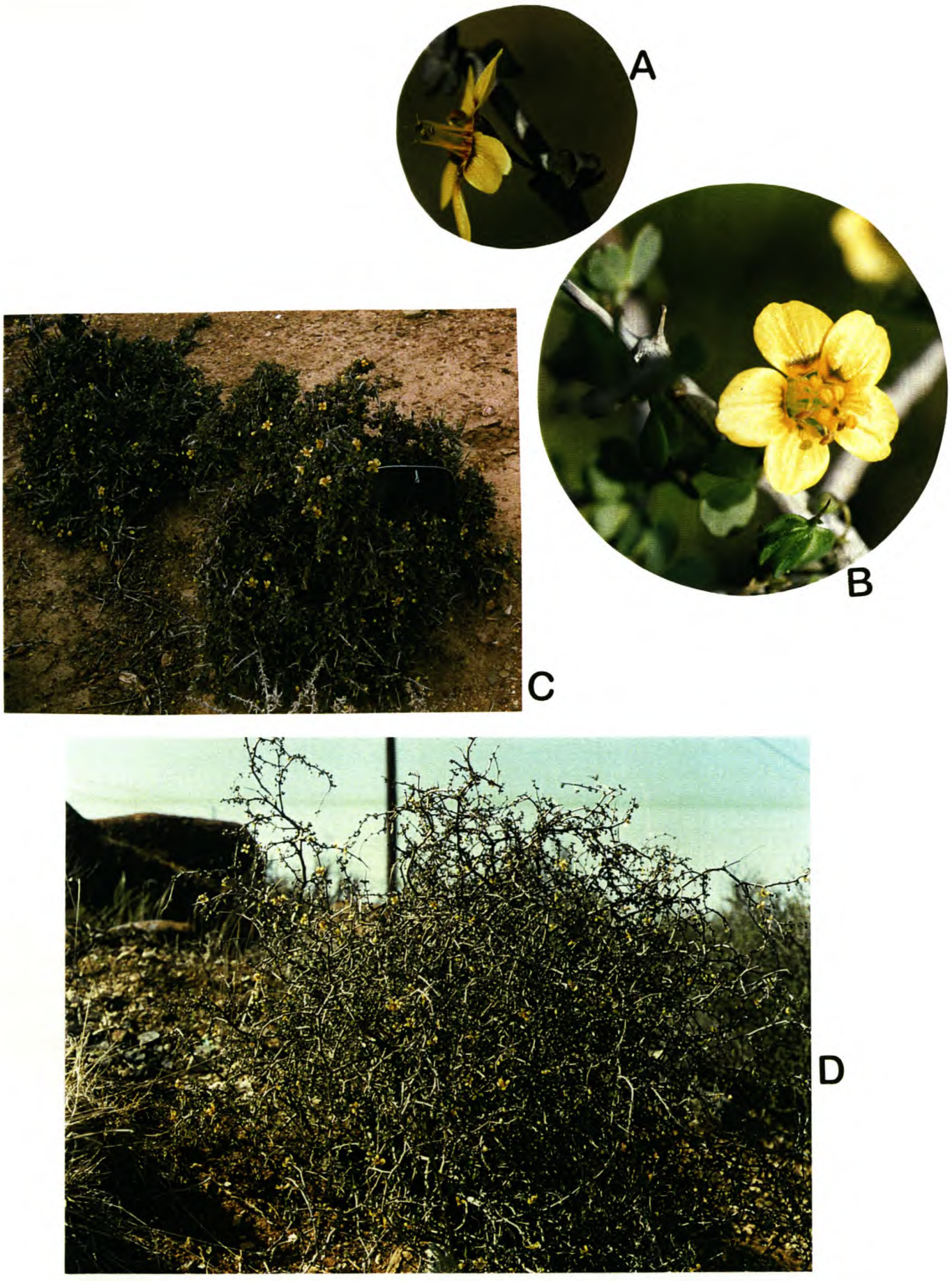


Figure 7.42.1. *Z. lichtensteinianum*. A, D, *Van Zyl 4306*; B–C, *Van Zyl 4226*. A, side-view of flower; B, twig with flower and immature, winged fruit; C, excessively grazed shrub near Prins Albert; D, habit near Nieuwoudtville.

towards the east it receives a precipitation of 50—500 mm per year predominantly in the summer to autumn. Where the two regimes overlap, rainfall occurs throughout the year.

Populations are large, consisting of scattered individuals spread over large areas. *Z. lichtensteinianum* is palatable resulting in seedlings and young plants being rare and excessive grazing damage being common (Figure 7.42.1.C). Older shrubs have smaller, bronze coloured leaves and are often lichen-covered. *Z. lichtensteinianum* is drought deciduous (Le Roux *et al.* 1994). After rains it quickly recovers to a green, leafy state, simultaneously flowering over the total length of the stems and not only at the apices of branches. Herbarium specimens made during this stage are often misidentified because of the small size and subpetioled state of the leaves.

Flowering occurs throughout the year with a peak during Spring and mature fruits are shed shortly after flowering. This species produces an abundance of fruits when not overgrazed. Because *Z. lichtensteinianum* is widespread with many and large populations, it seems not to be no threatened at present.

Common names: vaalspekbossie, spekbos, teebos.

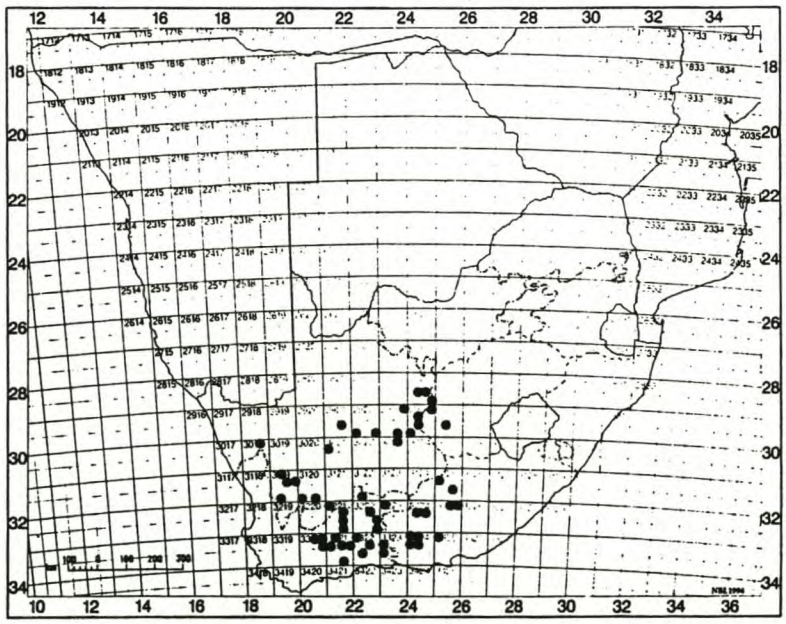


Figure 7.42.2. Geographical distribution of *Z. lichtensteinianum.*

Specimens examined

–2824 (Kimberley): Langverwacht, Kimberley (–CB), *Acocks 292* (PRE); Barckly West (–DA), *Cooke SAM 52268* (SAM); Benaawdheidfontein, Kimberley (–DD), *Acocks H990* (PRE).

–2921 (Kenhardt): Jagbult, 40 miles W of Marydale (–DA), *Story 1096* (PRE).

–2922 (Prieska): Memes-Pan 107, N of Kielder farmhouse (–CC), *Le Roux & Lloyd 169* (PRE); Keikam's Poort (–DD), *Pole-Evans H18820* (PRE).

–2923 (Douglas): 6 miles N of Orange and Vaal River junction (–BB), *Anderson 614* (PRE); 17 M W of Douglas (–BB), *Barker 661* (NBG); 6 km from Strydenburg on way to Prieska (–DC), *Herman 631* (PRE).

–2924 (Hopetown): 44 km N of Hopetown on way to Kimberley (–AD), *Herman 648* (PRE); 10 km W of Jacobsdal (–BB), *Zietsman 132* (PRE); Veld at Grange, Herbert (–CB), *Moran s.n.* (NBG, *PRE 45982*); 69 km W of Petrusville on way to Strydenburg via Kraankuil (–CC), *Herman 617* (PRE).

–2925 (Jagersfontein): Veld reserve plot 52, Fauresmith (–CB), *Henrici 3609* (PRE).

–3018 (Kamiesberg): Vaalputs, nuclear waste site (–BA), *Perry 3229* (NBG).

–3021 (Vanwyksvlei): Jan Louwskolk, S of Zwartkop (–AC*), Thompson 3130* (NBG).

–3023 (Britstown): Dam on Agterplaas, Britstown (–BA), *Retief & Germishuizen 99* (PRE);.

–3118 (Vanrhynsdorp): Bitterfontein, Namakwaland (–AB), *Zeyher 277* (SAM x 2).

–3119 (Calvinia): Kareeboom, Calvinia - Loeriesfontein (–AB), *Burger & Louw 246* (NBG); 16 M N of Calvinia (–BB), *Johnson 571* (NBG); Between Calvinia and Middlepoort (–BC), *Lewis 2940* (SAM); Vanrhynshoek, Hantam (–BD), *Thompson 2363* (NBG, PRE); Soutpan, E of Botterkloofpas, Calvinia (–CD), *Van Zyl 4221* (NBG).

–3120 (Williston): Kleinefontein 886, Roggeveld Escarpment (–CC), *Cloete & Haselau 109* (NBG); Snyderspoort through the Basterberge (–DC), *Thompson 3160* (NBG).

–3122 (Loxton): Snydersfontein, NW of Beaufort West (–CD), *Van Zyl 4162* (NBG).

–3125 (Steynsburg): Bangor farm, Middelburg (–AC), *Bolus 14035* (BOL); Conway farm, Middelburg (–CB), *Gilfillan s.n.* (BOL); Middelplaats, 25 km WNW of Hofmeyer (–DA), *Powrie 805* NBG).

–3221 (Merweville): 30 M NE of Sutherland (–AA), *Van Breda* 2020 (PRE); Past Muggiefontein on way to Theekloofpas (–BC/DA), *Van Zyl 3735* (NBG); Near Prince Albert Road Station (–DC), *Bolus 6054* (BOL).

–3222 (Beaufort West): Witgranaatvlakte, Karoo National Park (–BC), *Bengis 330* (PRE); Rystkuil, Beaufort West (DB), *Retief & Reid 268* (PRE); Aardoorns, road to Blouwater, Beaufort West (–DD), *Retief & Reid 110* (PRE).

–3223 (Rietbron): Courlandskloof, Nelspoort (–AA), *Pearson 732* (NBG).

–3224 (Graaf-Reinet): Karoo National Reserve, Graaf-Reinet (–AD), *Linger 2057* (PRE); N of Graaf-Reinet (–BC), *Bolus 279* (BOL); E sector of Karoo Nature Reserve, Graaf-Reinet (–BC), *Coetzee 15* (PRE).

–3225 (Somerset East): Rietfonteinvlakte, NW of Cradock (–BA*), Van Zyl 4176* (NBG); Salsolla flats, 8 km from Cradock on way to Tarkastad (–BA), *Adamson D229* (PRE); Commandodriftdam Nature Reserve, 40 km E of Cradock (–BB), *Palmer 803* (PRE).

–3320 (Montagu): Ghaapkop, W foothills, Matjiesfontein (–BA), *Van Zyl 3977* (NBG); Whitehill Karoo garden (–BA), *Compton 7491, 7786, 11215, 13379* (NBG); 17 km N of Matjiesfontein along N1 (–BA), *Van Wyk 518* (NBG); Varsbokkraal, S of Matjiesfontein (–BB), *Van Zyl 3981* (NBG); Rooihoogte, Laingsburg (–BD), *Compton 8686* (NBG).

–3321 (Ladismith): Nuwejaarskraal, NE of Laingsburg (–AB), *Van Zyl 3720* (NBG): Buffelsvlei, 8 km W of Grootrivier bridge (–AC), *Van Zyl 3707* (NG); Gamkapoort Nature Reserve (–BC), *Laidler 627* (NBG); Plot 47, Gamkapoort Nature Reserve (–BD), *Erasmus 183, 189* (NBG); Pretoriuskraal, Little Karoo (–DC), *Laidler 504* (NBG).
–3322 (Oudshoorn); Tygerberg, near Prince Albert (–AA), *Marloth 4467* (NBG, PRE); Near Prince Albert (–AA), *Tugwell s.n.* (BOL 13990); Meiringspoort, at 18th milestone from De Rust (–BC), *Van Zyl 3624* NBG, PRE); Near Vlakteplaas, E of De Rust (–BC), *Van Zyl 4190* (NBG); Between Outeniguapas and Oudshoorn (–CB), *Winkler 81* (NBG); 3 km S of Blossom turn off, Oudshoorn (–CB), *Van Zyl 3940* (B, NBG, PRE, S, WIND).
–3323 (Willowmore): Hills S of Uniondale Road Station (–AC), *Fourcade 3582* (NBG); At Vetvlei entrance, N of Uniondale (–CA), *Van Zyl 3640* (B, NBG, PRE, S, WIND).
–3324 (Steytlerville): Kloof between Meden and Pokkiesfontein, NW of Steytlerville (–AA), *Van Zyl 4186* (NBG); Near Heuningklip, N of Steytlerville (–AA), *Van Zyl 4184* (NBG); Near Mara, NW of Steytlerville (–AA), *Van Zyl 4188* (NBG); Near Goedehoop, N of Steytlerville (–AB), *Van Zyl 4183* (NBG); On flats, Nashville, Steytlerville karoo (–AC), *Hilton-Taylor 449* (NBG); N of Noorspoort, Mt Stewart turn off, Steytlerville (–AD), *Van Zyl 4181* (GRA, NBG).
–3325 (Port Elizabeth): Toekomst, Sunday's River Valley, Somerset East (–AA), *Long 230* (GRA).
Unknown or no precise locality: Tarkastadt, *Adamson D229* (PRE); I'us in hills, *Schlechter 11402* (Z); *Eckl.& Zeyh. 763*, Gauritzrivier deserti (SAM).

7.43 Zygophylum incrustatum *Sond.* in Flora capensis 1 : 362 (1860); Huysst.: 75 (1937). TYPE: Zwischen Beaufort and Rhinosterkopf, 2500 - 3000', *Drège s.n.* (S!, lecto., designated here); Fish River, *Zeyher 278* (S!); Zeekoeirivier 5000', collector? n.v.: Cradock, Tarka River 3000 - 4000' collector? n.v. Two of the syntypes given by Sonder are mounted together on one sheet in S. On the left are three twigs, *Zeyher 278* and on the right Drège s.n. "b", annotated on a small blue label by E. Meyer which is the lectotype.

Rounded to spreading, many-stemmed shrub, reaching a height and diameter of 1.0 m. *Stems*: old stems nude, grey, with rough bark; young branches spreading, curved, flexible, prominently white, densely pustulate, bearing short, alternate, spike-like branchlets, at first a nude spine which eventually becomes leafy branchlets or remain as leafless, single or divided spines along stems or at apices of branches, young stems round in cross section and without any lateral ridges. *Leaves* opposite, petiolate, bifoliolate; rachis apex widely triangular or subrotund, reflexed, 1 x 1 mm; petiole adaxially grooved, 3—4 mm long; leaflets conduplicate

or open, articulate, sparsely covered with unicellular glands, elliptic, apex obtuse and base rounded, 5–7 x 2–3 mm; stipules widely triangular, base cordate, reflexed, caducous, one on ventral side and one on dorsal side of stems, 1–2 x 2–3 mm. *Flowers* solitary, axillary. *Pedicel* 5—7 mm long. *Sepals* 5, obovate, some with membranous margins, 4–5 x 3 mm. *Petals* 5, obovate, apex obtuse, emarginate, base with a claw, deep yellow, unmarked, 9–10 x 3–4 mm. *Nectar disc* fleshy, papillate, regularly 10-angled. *Stamens* 10; filaments terete, 8—10 mm long; staminal scales 10, simple, oblong, upper margin finely lacerate, 2.5–3.0 x 1 mm, ± 1/3 as long as filament. *Ovary* 5-lobed; style terete; stigma simple. *Fruit* a drooping, ovoid, 5-lobed, loculicidal capsule, each lobe with a prominent central ridge where splitting will occur, apex acute, black when dried, 9–10 x 6 mm. *Seed* oblong, 1 per locule, 5 x 2 mm, light brown with a narrow white aril, testa smooth and glossy, producing brownish, structured mucilage with long spiral inclusions of a uniform width when wet (Figure 7.43.1).

Diagnostic characters and affinities

Z. incrustatum is distinguished by its widely triangular, cordate stipules, by its sparsely glandular leaflets (Kuun 1997), by the presence of spines and by its densely pustulate white stems. These are unique characters for the southern African species of *Zygophyllum*. The epithet *incrustatum* is Latin for coating or crust and refers to the white, pustulate coating of the stems. *Z. incrustatum* is related to the species in § *Capensia* with petiolate leaves and staminal scales without a border of papillae like *Z. lichtensteinianum*, *Z. debile* and *Z. maritimum,* but it remains isolated with regard to its vegetative morphology and does not show any close affinities. *Z. incrustatum* often grows together with Z. *retrofractum, Z. lichtensteinianum* and *Z. microcarpum,* but is readily distinguished from all the species by its unique diagnostic characters. Table 7.10 summarizes the characters of the species in § *Capensia* with petiolate leaflets.

Distribution and ecology

Z. incrustatum occurs in central South Africa, from Kimberley in the north and Carnarvon in the west to Aliwal North in the east and further south in the Groot

Figure 7.43.1. *Z. incrustatum, Van Zyl 4270.* A, leafy twigs with green fruits, white stems with spines and yellow flowers; B, white stems with dense pustules and a flower in side-view; C, habit near Hutchinson.

Karoo from Beaufort West in the West to as far east as Somerset East (Figure 7.43.2). It occurs in vegetation classified as **Savanna Biome**: Kimberly Thorn Bushveld (Van Rooyen & Bredenkamp 1996); **Grassland Biome**: South-eastern Mountain Grassland (Lubke et al., 1996) and in all the subdivisions of the **Nama Karoo Biome** (Hoffman 1996). Altitudes range between 700—1300 m above sea level. Rainfall occurs mainly in late summer and autumn and is between 50—600 mm per year. The substrates of the Nama Karoo Biome is lime-rich soil overlying rock with a grassy, dwarf shrubland vegetation. In the Savanna Biome the substrates are sandy to loamy sands over calcrete, covered with trees and grasses. The Grassland Biome occurs on a predominantly volcanic substrate with sandstones.

Populations of this species are localized or scattered over large areas. It is sometimes the dominant species in an area. Grazing damage does occur and can also be seen on herbarium specimens. *Z. incrustatum* is considered a "valuable karoo bush" and called "best sheep plant" (communication with farmers). However, Le Roux *et al.* (1994), does not consider this species as valuable fodder because of its spiny nature and leaf shedding during droughts. Flowering period is from October to April. *Z. incrustatum* is a widespread species and seems not to be threatened at present.

Common names: witkaree, spekboskareedoring, skeleton bush.

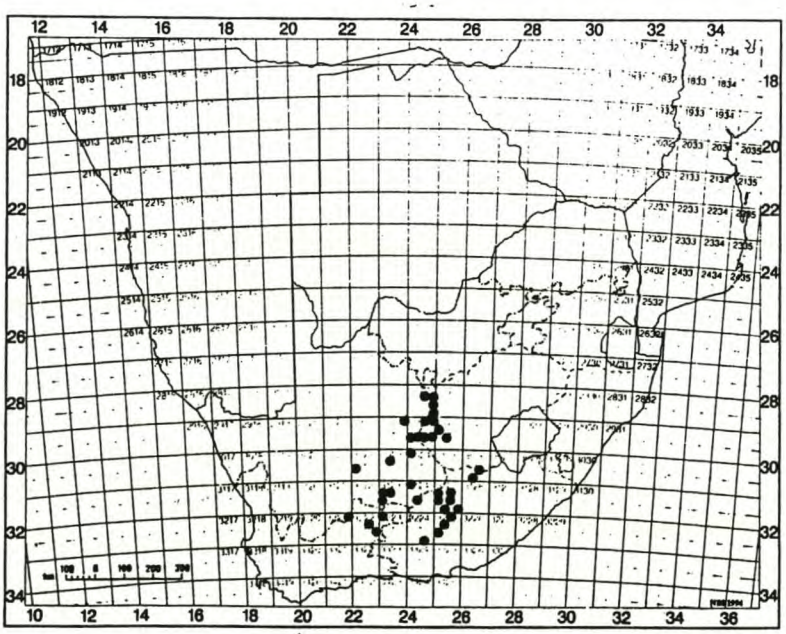


Figure 7.43.2. Geographical distribution of *Z. incrustatum*.

Specimens examined

–2824 (Kimberley): River View in Windsorton (–BC/BD), *Acocks H938* (PRE); Snyderskraal, Murraysburg (–DB), *Tyson 432* (SAM); Kimberley (–DB), *Marloth 731* (PRE); Benaawdheidfontein (–DD), *Acocks H989* (PRE); Road from Kimberly to Jacobsdal (–DD), *Schweickerdt 1144* (PRE).
–2923 (Douglas): Near Douglas (–BB), *Kotze 808* (PRE).
–2924 (Hopetown): Between Station and Richie, Modder River (–BA), *Smith 2362* (PRE); Heuningneskloof, Jacobsdal (–BA), *Phillips 3447* (PRE); Modderrivier Bridge, between Kimberley and Jacobsdal (–BB), *Schweickerdt 1146* (PRE); Near Hopetown (–CA), Muskett s.n. (BOL 2048); Ramah, Fauresmith (–CB), *Anderson L8* (PRE); Grange Railway Station (–CB), *Pole-Evans H11600* (PRE); Groenpan, Jacobsdal (–DA), *Anderson J29* (PRE); Camp above Luckhoff (–DB), *Smith 5326* (PRE).
–2925 (Jagersfontein): On the Rietrivier near Koffiefontein (–AC), *Burtt-Davy s.n.* (PRE 12409); Farm Uitdraai to Telegraafsfontein, Fauresmith (–CB), *Smith 4521A* (PRE); Fauresmith Veld Reserve (–CB), *Henrici 2669* (PRE).
–3022 (Carnarvon): Renosterkolk, Carnarvon (–CA), *Acocks 1707* (PRE).
–3023 (Britstown): Vrolikspan, Britstown (–AD), *Retief & Germishuizen 191* (PRE).
–3024 (De Aar): Potfontein, De Aar (–AA), *Smith 2813* (PRE).
–3026 (Aliwal North): 20 miles from Bethulie on Aliwal North road (–CD), *Storey 2045* (PRE); Excelcior farm, district Albert (–DA), *Burrows 2406* (PRE).
–3123 (Victoria West): Near the Reservoir at Victoria West (–AC), *Smith 2400* (PRE); At the turn in to Hutchinson (–AC), *Van Zyl 4270* (NBG, PRE, S, WIND); Vlekfontein road, Hutchinson (–AD), *Van Zyl 4269* (NBG, PRE); Hutchinson (–CA), *Burtt-Davy 17589* (BOL); Hutchinson Station (CA), *Nel s.n.* (STE 15811 in NBG); Flats at Victoria West (–CA), *Jooste 328* (PRE).
–3124 (Hanover): Grootfontein, 31 km N of Richmond (–AA), *Van Zyl 4268* (NBG); Zeekoe River (–CB), *Drège s.n.* (PRE 24737).
–3125 (Steynsburg): Bangor farm, Middelburg (–AC), *Bolus 14094* (BOL); Grootfontein, Middelburg (–AC), *Verdoorn 1541* (PRE); Just N of Bangor Station, Middelburg (–AC), *Van Zyl 4127* (NBG); Between Middelburg and Tafelberg farm (–AC/CA), *Hutchinson 3105* (PRE); Volstruispoort, Britstown (–BC), *Retief & Germishuizen 13* (PRE); Kafferskraal, Steynsburg (–BC), *Retief & Germishuizen 213* (PRE); Tafelberg farm, 5 k SE of Middelburg (–CA), *Van Zyl 4173* (NBG); Tafelberg mountain, next to R32, Middelburg (–CA), *Van Zyl 4174* (NBG, PRE); 4 km N of Visrivier Station, Middelburg (–CD), *Van Zyl 4175* (NBG); Middelplaats, ± 25 km WNW of Hofmeyer (–DA), *Powrie 809* (NBG); Spitskop contours, Vlekpoort Conservation area, Maraisburg (–DD), *Archibald 2827* (GRA).
–3221 (Merweville): Bruinrug flats, Beaufort West (–BB), *Shearing 4522* (PRE).
–3222 (Beaufort West): Flats near Gholf course, Beaufort West (–BC), *Shearing 943* (PRE); Beaufort West (–BC), *Thode s.n.* (STE 4842 in NBG); Rystkuil farm, Beaufort West (–DB), *Retief & Reid 297* (PRE); Near Saucy'skuil, SE of Beaufort West (–DB), *Van Zyl 4166* (NBG).

–3223 (Rietbron): Nelspoort, Beaufort West (–AA), *Martin 949* (NBG).

–3224 (Graaff-Reinet): Teasdale (–DC), *Hoffman 1036* (GRA).

–3225 (Somerset East): Mountain Zebra Park, Cradock (–AD), *Zietsman 1309* (PRE); Along Cookhouse road, S of Cradock (–BA), *Van Zyl 4177* (NBG); Flats E of Cradock (–BA), *Adamson D240* (PRE); Vogelrivier , Somerset East (–CA), *MacOwan 1588* (BOL, PRE);

Unknown or no precise localities: Cradock, *Cooper 498* (TCD); Queenstown, *M.E.B. 620* (TCD).

7.44 **Zygophyllum maritimum** *Eckl. & Zeyh.*, Enumeratio plantarum... 1 : 96 (1835); Sond.: 361 (1860). TYPE - Eastern Cape: In locis saxosis (altit. l) litoris prope "Cap Recief et Port Elizabeth" (Uitenhage), *Ecklon & Zeyher 757* (S!, lecto., designated here, C!, KIEL, SAM!).

Zygophyllum uitenhagense *Sond.*: 361 (1860); Huysst.: 74 (1937); Bond & Goldblatt: 437 (1984). TYPE - Eastern Cape: In locis saxosis (altit. l) litoris prope "Cap Recief et Port Elizabeth" (Uitenhage). Oct. - Febr., *Ecklon & Zeyher 757* (S!, lecto., designated here, C!, KIEL, SAM!).

Because *Z. maritimum* and *Z. uitenhagense* are conspecific, the older name, *Z. maritimum* Eckl. & Zeyh., is reinstated.

Low shrublet, sparsely branched, branches prostrate or scrambling over or through other shrubs, reaching a length of 1.5–2.0 m. *Stems*: old stems nude, bark rough, gray, cracked; younger branches smooth, leafy, flat on ventral side, with prominent, lateral ridges. *Leaves* opposite, bifoliolate, petiolate, glabrous, petiole adaxially grooved, 1—3 mm long; rachis apex triangular, brown 0.5–1.0 x 0.5 mm; leaflets secund, asymmetrical, articulate, green, obovate or elliptic, rarely slightly succulent, 14–19 x 5–10 mm, apex rounded or acute, mucronate, base narrowed; stipules narrowly triangular, brown, reflexed, base semi-permanent, two on ventral and two on dorsal side of stems, 1.0–1.5 x 0.5–1.0 mm. *Flowers* solitary or 2 together, axillary. *Pedicel* 8—25 mm long. *Sepals* 5, ovate or obovate, apex acute or obtuse, some with membranous margins, 5–6 x 3–5 mm. *Petals* 5, widely obovate, 11–14 x 7–9 mm, apex obtuse, wavy, emarginate, base with a short claw, cream coloured or yellow, variously marked at base with darker yellow, red or brown, always more so on two posterior petals. *Nectar disc* fleshy, papillate, regularly 10-angled. *Stamens* 10; filaments terete, 5—6 mm long; staminal scales 10, simple, oblong or obovate,

apex truncate or obtuse, margins lacerate, 2–3.5 x 1–2 mm, ± 1/2 the length of the filament. *Ovary* spheroid, vaguely 5-lobed; style terete; stigma simple. *Fruit* a drooping, oblong or spheroid, loculicidal capsule, with an obtuse apex and base, not ridged but with visible sutures, 12–15 x 10–13 mm, brick coloured on sunny side. *Seed* oblong or nearly round, 1—4 per locule, 4–5 x 2.5–3 mm, dark brown with a white aril, testa glossy, smooth, producing structured mucilage with long spiral inclusions of a uniform length when wet (Figure 7.44.1).

Diagnostic characters and affinities

Z. maritimum is distinguished by its scrambling or prostrate habit with long, weak, radiating branches reaching a length of 2 m, by its petiolate leaves and by its large, 12–15 x 10–13 mm in size, oblong or spheroid fruits, which are without ridges but with faint sutures visible. With regard to leaf and flower morphology, it is allied to *Z. debile* which has similar shortly petiolate leaves and staminal scales without a border of papillae on its surface as well as a filament to scale ratio of 2 : 1. When sterile these two species are distinguished by the different number of stipules found on the dorsal side of their stems, *Z. debile* with one only and *Z. maritimum* always with two. When in flower but without mature fruits, *Z. maritimum* is distinguished by its spheroid ovary with vague sutures visible, whereas the ovary of *Z. debile* is 5-lobed and rudimentary winged. The mature fruits of these two species differ greatly, those of *Z. maritimum* are oblong or spherical, without wings or ridges and those of *Z. debile* oblong and 5-winged. *Z. maritimum* can also be confused with *Z. fulvum* and *Z. flexuosum,* but the latter two species have sessile leaves. The epithet *maritimum* probably refers to the usually close to the shoreline distribution of this species. Table 7.10 summarizes the characters of the species in § *Capensia* with petiolate leaves.

Distribution and ecology

Z. maritimum occurs in a narrow strip along the southern coastline of South Africa, from Mosselbaai in the west to as far east as the Chalumna River mouth in the Peddie area and inland towards Grahamstown (Fig 7.44.2). It occurs in four of the

Figure 7.44.1. *Z. maritimum, 4178.* A, leafy twig with a cream-coloured flower marked in red; B, scrambling habit with long, weak branches, near Grahamstown.

five subdivisions of the **Thicket Biome**: Dune Thicket, Valley Thicket, Xeric Succulent Thicket and Mesic Succulent Thicket (Lubke 1996). It is of interest that its closest relative, *Z. debile*, is found in the fifth subdivision, namely Spekboom Succulent Thicket. In the Mosselbaai to Humansdorp area the winter months are wet and summers are dry and hot, whereas the rest of its distribution area receives rain during summer. Substrates are regic dune sands, lime-rich sandy clays or loams derived from the Cape Supergroup and Karoo Sequence (sandstones and shales). Flowering period is from April to November with a peak in early Spring. Populations are small and consist of occasional, scattered individuals, including seedlings and juveniles. This species has an extended distribution stretched out along the coastline with many known populations and although these populations are small, this species seems not to be threatened at present.

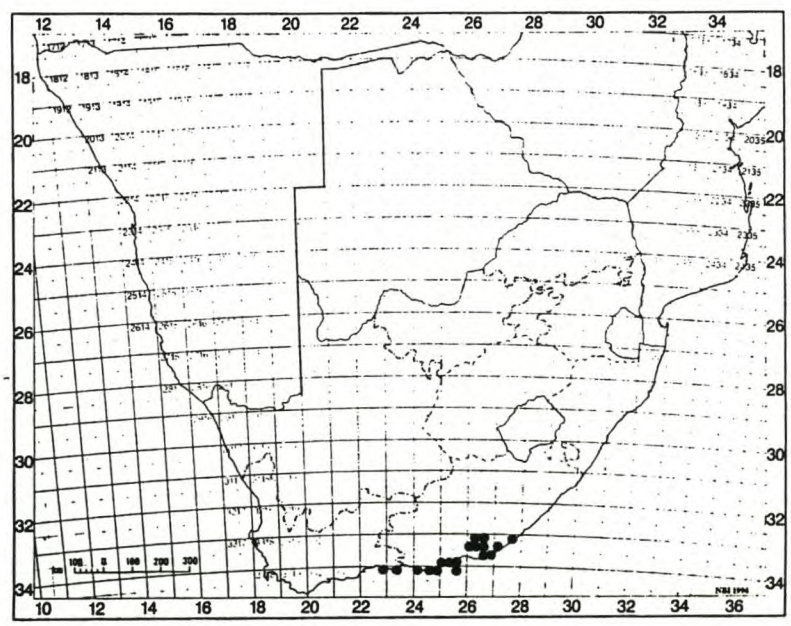


Figure 7.44.2. Geographical distribution of *Z. maritimum*.

Specimens examined

–3325 (Port Elizabeth): Near bridge over National road in Gamtoos Valley (–CC), *Acocks 16114* (PRE): In woody and dry places of the Karoo near Swartkopsrivier, Uitenhage (–CB/CD), *Ecklon & Zeyher 756* (PRE, S, SAM); Zwartkopsrivier (–CB/CD), *Zeyher 2146* (SAM); Uitenhage (–CD), *Thode 1079* (PRE); Markman Industrial area, 10 M N of Port Elizabeth (–DC), *Dahlstrand 1780* (NBG); Redhouse, Port Elizabeth (–DC), *Rogers 3610* (NBG); *Paterson 2051* (BOL); Humewood, Port Elizabeth (–DC), *Long 454* (PRE); *Paterson s.n.* (TM 25710); *Compton 13157* (NBG); Port Elizabeth

(–DC), *Paterson 2531* (BOL, SAM); *Drège 55* (GRA); Port Elizabeth Airport (–DC), *Dahlstrand 3087* (GRA); Close to the sea at Swartkops (–DC), *Theron 1063* (PRE); 10 M N of Port Elizabeth (–DC), *Dahlstrand 280* (GRA).

–3326 Grahamstown): Near clay pits, Cradock road, Albany (–AB), *Barker 10909* (NBG); Assegaaibosch (–AC), *Fourcade 1200* (NBG); ± 10 km NW of Grahamstown (–AD), *Van Zyl 4178* (BOL, GRA, NBG, PRE); 5 M from Grahamstown on Cradock road (–AD), *Michie 52* (GRA); *Brink 400* (GRA); Off Cradock road, beyond Bible Monument, Albany (–AD), *Shumane s.n.* (PRE 668255); Boesmansrivier mouth (–AD), *Archibald 3540* (GRA); *Galpin 10666* (BOL, PRE): *Archibald 3645, 5564* (PRE); *Barker 1390* (NBG); *De Vos s.n.* (STE 18744 in NBG); On Bothasbergen near Grahamstown (–BA), *MacOwan 966* (SAM); Hill above West Hill Station, Grahamstown (–BC), *Daly 888* (PRE); Commonage near Golf course, Grahamstown (–BC), *Rennie 360* (BOL); 6 M N of Grahamstown (–BC), *Dyer 2397* (PRE); In scrub, Grahamstown (–BC), *Galpin 156* (GRA); Sand dunes near lagoon at Kasuka River mouth (–DA), *Phillipson 352* (PRE); Port Alfred (–DB), *Marloth 8552* (PRE); *Tyson s.n.* (TM 17237); *Schonland 1539* (GRA); *Potte 228* (BOL); *White 65* (PRE); Kowie West, Albany (–DB), *Tyson s.n.* (BOL 13278); *Gillett 2008* NBG); Salt Vlei, Port Alfred (–DB), *McCallan s.n.* (PRE 645261); W edge of bush towards pier, Kowie (–DB), *Britten 1908* (PRE).

–3327 (Peddie): Riparian schrub E of Fish River (–AC), *O'Callaghan 1075* (GRA); Edge of dune thicket at Chalumna River mouth (–BA), *Arnold 583* (PRE).

–3422 (Mossel Bay): Edges of Milkwood forest at Goukamma (–BB), *Nat. Cons. 135* (PRE); Hillside above bank of Goukammarivier (–BB), *Duthie s.n.* (STE 29852 in NBG); In bush at Lake Pleasant (–BB), *Wurts 2238* (NBG); *Van Zyl 3631* (BOL, GRA, NBG, PRE); Near Platbank in Groenvlei area (–BB), *Van Zyl 3633* (NBG); *Hugo 1972* (NBG, PRE).

–3423 (Knysna): Steep cliffs, N aspects of Robberg (–AB), *Van Zyl 3939* (GRA, NBG); Sandy hills, Plettenbergbaai (–AB), *Michell s.n.* (BOL 16086).

–3424 (Humansdorp): Coastal scrub at Oudebos Strand (–AA), *Levyns 11472* (BOL); Near seashore at Eersterivier, Humansdorp (–AA), *Fourcade 2453* (BOL); Geelhoutboomrivier, Humansdorp (–BA/BB), *Fourcade 2219* (BOL); *Christie 29* (GRA); Jeffreys Bay (–BB), *Duthie 1123* (NBG); *Taylor 5140* (NBG); Erf in Cape St. Francis (–BB), *Van Zyl 3938* (NBG).

–3425 (Skoenmakerskop): At Skoenmakerskop (–BA), *Bokelman 4 PL39* (NBG); U.P.E. Campus Nature Reserve (–BA), *Moore 42* (PRE); Rocky places near sea at Cape Recife, Port Elizabeth (–BA), *Ecklon & Zeyher 757* (C, S, SAM).

Unknown or no precise localities: No locality, *Guthrie 4714*, (NBG); *Zeyher 2124* (P, Z); Igoda Mouth, *Sidey 1171* (PRE); Welbedachtrivier, Humansdorp, *Fourcade 724* (BOL); Hills between Zwartkop and Sondagsrivier, *Ecklon 425* (SAM, TCD); Near Grahamstown, *Bolton s.n.* (TCD); Albany, *Hutton s.n.* (TCD).

7.45 **Zygophyllum debile** *Cham.* in Linnaea, 5 : 45 (1830); Don: 771 (1831); Eckl. & Zeyh.: 96 (1835); Sond.: 361 (1860); Huysst.: 74 (1937); Bond & Goldblatt:

437 (1984). TYPE - Eastern Cape: Cango, Groeneberg, *Mundt 14* (S!, lecto, designated here).

Compact, decumbent shrublet or sometimes scrambling into other shrubs, reaching a height of 0.2 (–0.6) m and a diameter of 1 m. *Stems*: old stems nude, bark rough, gray, cracked; younger stems smooth, leafy, flat on ventral side, with prominent, lateral ridges. *Leaves* opposite, bifoliolate, petiolate; petiole adaxially grooved, 1—4 mm long; rachis apex triangular, brown, 0.5–1.0 x 0.5 mm, reflexed; leaflets asymmetrical, articulate, glaucous, secund, midrib visible on lower half of lamina, obovate, ovate or elliptic, flat or with recurved margins, sometimes becoming succulent with age, 11–26 x 4–7 mm, apex rounded or acute, base narrowed; stipules narrowly triangular, brown, reflexed, base semi-permanent, on ventral side of the stem usually two together or rarely one only and then with apex notched, on dorsal side one only, 1–2 x 1 mm. *Flowers* solitary or sometimes 2 together, axillary. *Pedicel* 9—10 mm long. *Sepals* 5, ovate or obovate, sometimes glandular on dorsal surface, apex acute or rounded, some with membranous margins, 5–7 x 2–4 mm. *Petals* 5, widely obovate, 13–14 x 6–8 mm, apex rounded, emarginate, undulate, base with a short claw, cream coloured or yellow, variously marked at base with red, deeper yellow or brown, always more so on two posterior petals. *Nectar disc* fleshy, papillate, regularly 10-angled. *Stamens* 10; filaments terete, 7—9 mm long; staminal scales 10, simple, oblong or obovate, margins lacerate, apex obtuse, 3.0–3.5 x 1.0–1.5 mm, ± ½ the length of the filament. *Ovary* oblong, 5-lobed, with rudimentary wings; style terete; stigma simple. *Fruit* a drooping, oblong, burgundy coloured, 5-winged, loculicidal capsule, 12–26 x 9–14 mm in size, wings 2 mm wide. *Seed* oblong, 4—7 per locule, 4.0 x 1.5–2.0mm, dark brown with a white aril, testa glossy, smooth, producing structured mucilage with long, spiral inclusions of a uniform width when wet (Figure 7.45.1).

Diagnostic characters and affinities

Z. debile is distinguished by its glaucous leaves with short, 1—4 mm long petioles and by its large, oblong, burgundy coloured, 5-winged fruits with wings of 2 mm in width. With regard to leaf and floral morphology it is allied to *Z. maritimum,* both

A

B

C

Figure 7.45.1. *Z. debile, Van Zyl 3691*. A, cream coloured flower illustrating the more prominently marked two posterior petals; B, branch with glaucous leaves and burgundy coloured, 5-winged fruits; C, compact, decumbent habit on shale in the Huisrivier Pass.

species have similar, petiolate leaves and similar staminal scales without a border of papillae on the surface and a similar filament to scale ratio of 2 : 1. When sterile these two species are distinguished by the different number of stipules on the dorsal side of their stems, *Z. debile* with one only and Z. maritimum always with two. When in flower, the ovary of *Z. debile* is 5-lobed and rudimentary winged, whereas the ovary of *Z. maritimum* is spheroid, with only vague sutures visible. The mature fruits of these two species differ greatly, those of *Z. debile* are oblong and prominently 5-winged (Figure 7.45.1.B) and those of *Z. maritimum* are spheroid, without wings or ridges, with sutures showing. Both species have a decumbent to nearly prostrate habit, *Z. debile* tending to be more compact (Figure 7.45.1.C), whereas *Z. maritimum* develops long, radiating, prostrate or climbing branches of up to 2 m. Table 7.10 summarizes the characters of the species in § *Capensia* with petiolate leaves.

Distribution and ecology

Z. debile has a somewhat disjunct distribution along the southern part of South Africa (Figure 7.45.2). In the western part of its distribution *Z. debile* is found on the lower slopes of the mountains surrounding the Little Karoo, from Ladismith in the west to Willowmore in the east. The eastern part of its distribution is centered around the Uitenhage and Grahamstown districts. *Z. debile* occurs in a vegetation classified as **Thicket Biome:** Spekboom Succulent Thicket on sandstone, quarsitic and shale substrata which receives rain mainly in autumn and spring and which experiences moderate temperatures with short periods of extremes; Xeric Succulent Thicket and Mesic Succulent Thicket (eastern range), on lime-rich, sandy loams derived from shales with rainfall for both areas ranging from 300—550 mm per year and occurring throughout the year (Lubke 1996); **Succulent Karoo Biome**: Little Succulent Karoo (Hoffman 1996), on shales and conglomerates with a low, winter rainfall of 150—300 mm per year and hot and dry summers; **Fynbos Biome**: Central Mountain Renosterveld, South & South-West Coast Renosterveld and Mountain Fynbos on sandstones, conglomerates and shales (Rebelo 1996) with rain occurring during winter and with hot and dry summers.
Populations are small, consisting of occasional or scattered individuals, often on steep, sunny slopes or cliffs. Grazing damage occurs and seedlings or young plants

are rare. The only plants surviving heavy grazing occur under shrubs or in other shrubs. Although this species is a decumbent shrublet , it sometimes scrambles into other shrubs, reaching a height of 0.6 m. One collector mentioned a 'questionable' diameter of several meters for *Z. debile*. Flowering period is from April to October with a peak occurring during Spring. Because of its large distribution and many populations occurring in several habitats, *Z. debile* seems not to be threatened at present.

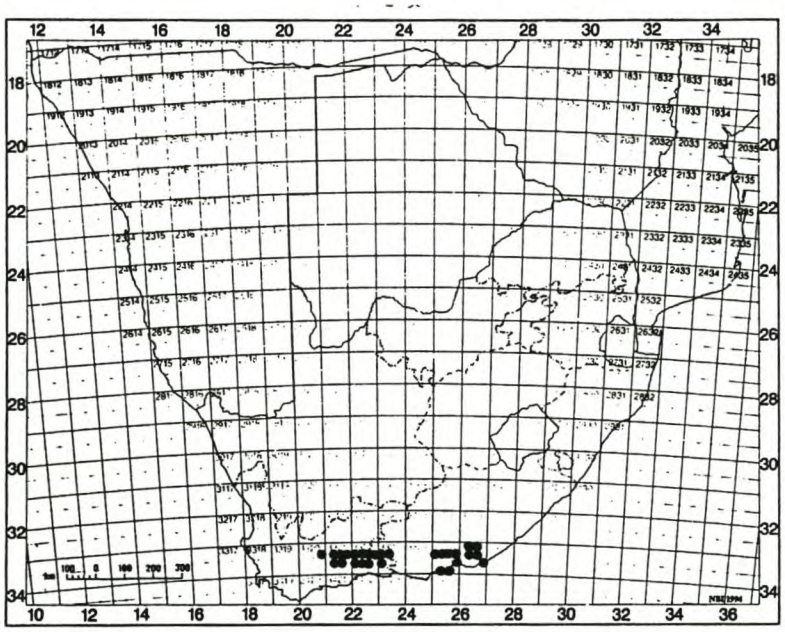


Figure 7.45.2. Geographical distribution of *Z. debile*.

Specimens examined

–3320 (Montagu): Top of Suikerdrifkloof Pass, near Ou Tol (–BD), *Van Zyl 3714* (NBG).

–3321 (Ladismith): Shady spots in Seweweekspoort (–AD), *Hugo 2582* (NBG); S entrance to Seweweekspoort (–AD), *Van Zyl 3943* (BOL, NBG, PRE, S); Mountainside in Huisrivierpas (–BC), *Van Niekerk 546* (BOL); *Van Breda 4465* (PRE); N slopes of Gamkaberg (–BC), *Boshoff P152* (NBG); E side of Huisrivierpas, near second bridge (–BC), *Van Zyl 3692* (NBG); Entrance to Bergplaas, W of Huisrivierpas (–BC), *Van Zyl 3691* (NBG); Limerick, E of Calitzdorp (–BD), *Van Zyl 4527* (NBG); Koppies between Ladismith and Vanwyksdorp (–CB), *Levyns 4220* (BOL); On range N of Sandberg, Ladismith (–DA), *Wurts 1374* (NBG).

–3322 (Oudshoorn): Cango Caves (–AC), *Gillett 1676* (NBG); *Van Zyl 3645* (BOL, NBG, PRE); On Groot Swartberg, above Groenfontein (–AC), *Vlok 45* (NBG); W of tar road on Boomplaas, Cango

Valley (–AC), *Moffett 76* (NBG, PRE); Shale slope below excavation site on Boomplaas, Cango Valley (–AC), *Moffett 165* (NBG, PRE); Swartbergpas road, near Cango (–AC), *Bolus 11730* (BOL); Rhenosterveld, near caves in Cango Valley (–AC), *Marloth 12140* (NBG); Top of Swartbergpas (–AC), *Dreyer s.n.* (STE 18745 in NBG); Limestone formations on Boomplaas, Cango Valley (–AC), *Van Zyl 3646* (NBG, PRE); Slopes on Nooitgedagt, W of Cango Caves (–AC), *Van Zyl 4528* (NBG, PRE); Frisgewaagd, E of Prins Albert (–AD), *Van Zyl 4515* (NBG, PRE); Wilgerdal, E of Prins Albert (–AD), *Van Zyl 4535* (NBG); 6 M SW by W of De Rust (–BC), *Acocks 18286* (PRE); Meiringspoort, W of Oudshoorn (–BC), *Goldblatt 1765* (NBG); Meiringspoort (–BC), *Van Zyl 3625* (NBG, PRE); Brakkloof near Olifantsrivier (–BD), *Bolus 1877* (BOL); Schoemanshoek, 13 km N of Oudshoorn (–CA), *Van Zyl 3647* (BOL, NBG, PRE); On Red Ecca formations, ±10 km S of Oudshoorn (–CA), *Van Zyl 3944* (NBG); Die Krans, between Oudshoorn and De Rust (–CB), *Van Zyl 3644* (BOL, GRA, NBG, PRE); Near water reservoir hill on Doornkraal (–DA*), Dahlstrand 2281* (NBG).

–3323 (Willowmore): Nietgenaamd Nature Reserve near Toorwater (–AC), *Hilton-Taylor 647* (NBG); S foothills of Antoniesberg (–AD), *Vlok 1352* (NBG); Between rocks on Vetvlei, Uniondale (–CA), *Markötter s.n.* (STE 8822, 25982, 25983 in NBG); Watermeul at Uniondale (–CA), *Van Zyl 3673* (NBG, PRE).

–3325 (Port Elizabeth): Between Roodewal and Bloukranz (–AC/AD), *Bolus 1877* (BOL); Bush in Addo National Park (–BC/BD), *Brynard 436* (PRE): Zuurkop in Addo National Park (–BD), *Botha 5879* (PRE); Uitenhage (–CD), *Thode A 635* (PRE); Between Coega and Zondagsrivier (–DB/DC), *Ecklon & Zeyher 759* (SAM).

–3326 (Grahamstown): ± 5 M from Grahamstown on road to Cradock (–AB), *Retief G 7* (GRA); Old railroad between Tootabi and Alicedale (–AD), *Archibald 5986* (GRA, PRE); *Johnson 986* (PRE); Pluto's Vale (–BA), *Story 2277* (GRA); Between Fort Brown and Botha's Ridge, Albany (–BA), *Acocks 12771* (PRE); Botha's Hill, near Grahamstown (–BA), *Daly 1039* (GRA); Grahamstown (–BC), *Karsten s.n.* (BOL 25107); Port Alfred (–DB), Hopewell farm, Bathurst (–DB), *Compton 19632* (NBG).

Unknown or no precise localities: Aangenaam, Oudshoorn, *Van Niekerk 470* (BOL); *Flanagan s.n.* (PRE 45980); Baakensvallei, *Drège 583* (GRA); Queens Pass, Albany, *Bayliss 2269* (B, NBG, Z); Cango, Uitenhage, *Compton 7204* (NBG); Albany Museum Garden, cultivated, *Skotile 6* (GRA).

7.46 Zygophyllum cretaceum *Van Zyl*, sp. nov., (§ *Capensia*), *Z. foetido* affinis sed caulibus manifeste cretaceis, fructibusque 5-lobatis, latioribus quam longioribus, seminibus per parietes tenues transparentes visibilibus differt (non caulibus griseis, fructibusque rotundatis, paulo longioribus quam latioribus, costis crassis, osseis, ut in *Z. foetido*). TYPE - Namibia: Altdoorn, NE of Ai-Ais, *Van Zyl* 3837 (NBG, holo., K, PRE, S, WIND).

Rounded, multi-stemmed shrub, reaching a height of 1.5 m high and a diameter of 2 m. *Stems*: old stems round in cross section, prominently white; young branches pale green, smooth, flat on ventral side and with weakly developed lateral ridges as well as several distal ridges. *Leaves* opposite, petiolate, bifoliolate; rachis apex green, triangular, patent, 3 x 2 mm; petiole adaxially grooved, 3—5 mm long: leaflets articulate, asymmetrical, obovate, dark green, rarely succulent with age, apex rounded, base oblique, 23–28(35) x 15–22(30) mm; stipules membranous, triangular, reflexed, two on ventral side and one on dorsal side of stem, 3 x 2 mm. *Flowers* solitary or two together, axillary. *Pedicel* up to 10 mm long. *Sepals* 5, ovate, apex acute, glabrous, 4–5 x 2.3–3.0 mm. *Petals* 5, elliptic or obovate, 10–11 x 3–5 mm, apex obtuse, base with a short claw, bright yellow, with red, V-shaped markings at base or unmarked. *Nectar disc* fleshy, papillate, regularly 10-angled. *Stamens* 10; filaments terete, 5.5—6.0 mm long; staminal scales 10, simple, oblong, margins lacerate, bordered with sparse or dense papillae or papillae concentrated on upper half of both surfaces but more on ventral side of scale, 2.5–3.0 x 1.0–1.3 mm, ± 1/3 the length of filament. *Ovary* spheroid, 5-lobed; style terete, stigma simple. *Fruit* a subspheroid, prominently 5-lobed, loculicidal capsule with a thin, disintegrating exocarp exposing the seeds, 3.5 x 5.0 mm. *Seed* vaguely kidney-shaped with obvious lateral grooves, 1 (2) per locule, 3.0 x 1.5 mm, black or dark brown with a small, white aril present, testa smooth, glossy, producing brown, structured mucilage with long, spiral inclusions of a uniform width when wet (Figure 7.46.1).

Diagnostic characters and affinities

Z. cretaceum is distinguished by its petiolate leaves, prominently white stems, (hence the specific epithet; Figure7.46.2.A,D) and by its small, subspheroid, 5-lobed fruits (Figure 7.46.2.C). When mature these fruits have a thin, weak exocarp that disintegrates, exposing the seeds (Figure 7.46.2.D). It is allied to *Z. foetidum*, *Z. leptopetalum* and *Z. macrocarpon* in vegetative characters. They all have similar, dark green, petiolate leaves differing only in size and similar erect or rounded, many-stemmed habits, often reaching into and over nearby plants. The stems of *Z. cretaceum* are round in cross section with several ridges and always prominently

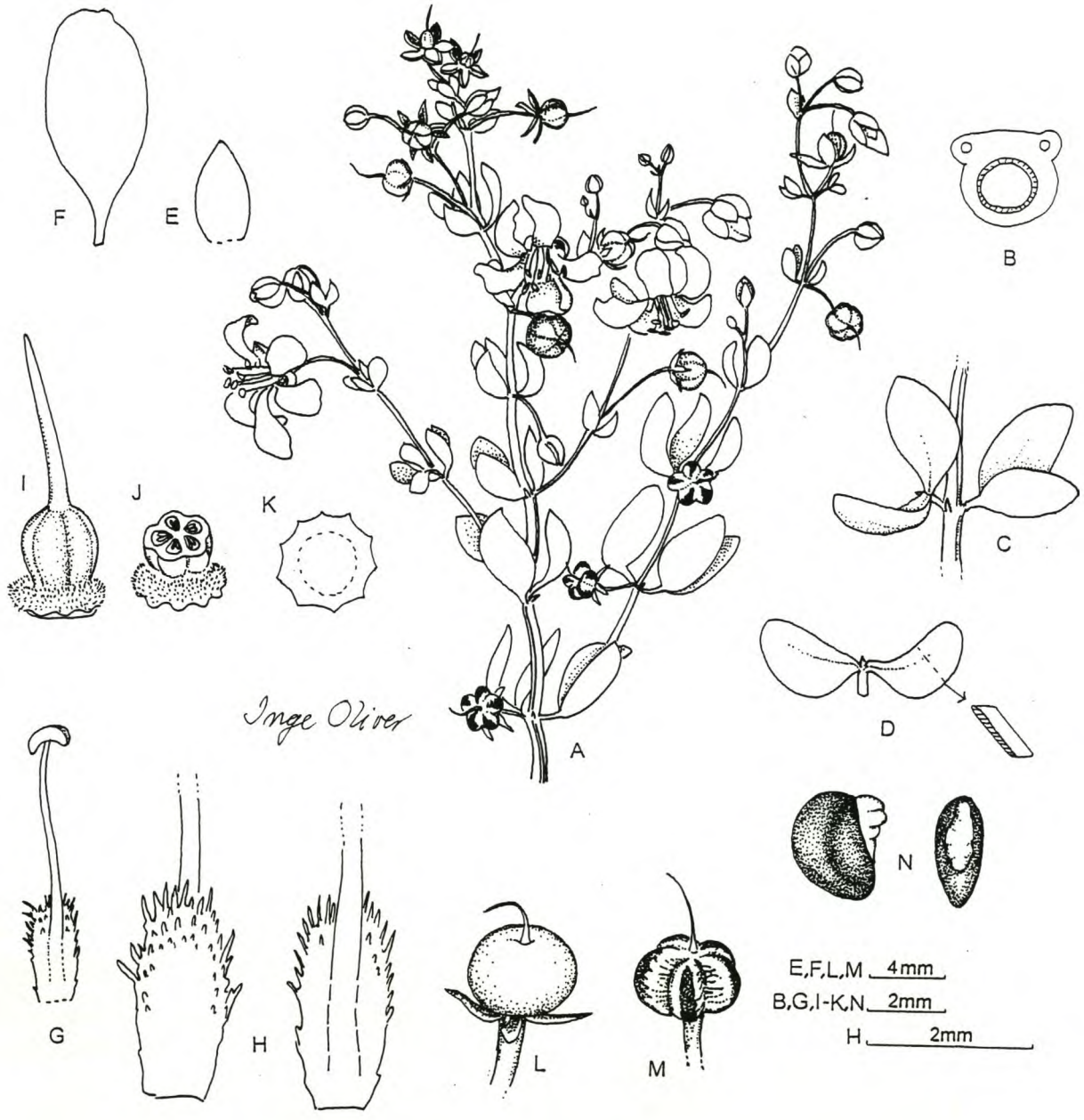


Figure 7.46.1. *Z. cretaceum*, *Van Zyl 4488*. A, flowering and fruiting branch, life-size; B, cross section of young stem; C, opposite, petiolate leaves; D, cross section of leaflet; E, sepal; F, petal; G, dorsal-view of staminal scale; H, ventral- and dorsal-view of staminal scale; I, ovary on papillate nectar disc; J, cross section of ovary; K, cross section of nectar disc; L, succulent, fresh fruit; M, 5-lobed, dry fruit with seed visible through disintegrating exocarp; N, side- and top-view of arillate seed.

Figure 7.46.2. *Z. cretaceum* A, *Van Zyl 4319*; B—D, *Van Zyl 4488*. A, nearly leafless state with white stems clearly visible; B, habit in dry streambed on wide, valley floor near Vioolsdrif; C, twig with unmarked, yellow flower and green fruits; D, twig with mature fruits, dark seeds clearly visible through thin fruit wall.

white. The old stems of *Z. macrocarpon* are round in cross section, but hollow and never white. The old stems *Z. foetidum* and *Z. leptopetalum* are either square or transversely elliptic in cross section and neither hollow nor prominently white. The fruits of *Z. cretaceum* are small and subspheroid, those of *Z. foetidum* and *Z. leptopetalum* slightly larger, and longer than wide, whereas *Z. macrocarpon* has large, prismatic, 5-winged fruits. The fruit walls of *Z. cretaceum* are thin, become nearly transparent, eventually disintegrate and expose the seeds whereas the somewhat similar shaped fruits of *Z. foetidum* and *Z. leptopetalum* differ in having thick, bony exocarps. Table 7.10 summarizes the characters of the species in § *Capensia* with petiolate leaves.

Distribution and habitat

Z. cretaceum occurs in the lower Orange River basin (Figure 7.46.3). On both sides the river has wide, exposed belts of rugged hills dissected by its tributaries. In these narrow, tributary valleys, often amongst large boulders, small populations of scattered individuals of *Z. cretaceum* occur (Figure 7.46.2.A), usually on the cooler southern and south-eastern slopes. *Z. cretaceum* also occurs in dry stream beds on wide valley floors (Figure 7.46.2.B). In Namibia collections were made near Witputz and Kolke, north of Rosh Pinah, and in the Ai-Ais area. In the Northern Cape it is found from the Richtersveld in the west to as far east as Pella. *Z. cretaceum* occurs in a vegetation classified as **Suculent Karoo Biome**: Upland Succulent Karoo (Hoffman 1996), with a rainfall ranging from 150 to 300 mm per year, occurring mostly during winter, and **Nama Karoo Biome**: Orange River Nama Karoo (Hoffman 1996), with a rainfall ranging from 150 to 350 mm rain per year, occurring during late summer and late autum. High temperatures are experienced during summers. This corresponds to the vegetation in which it occurs in Namibia and classified as Succulent Karoo Biome and Nama Karoo Biome (Irish 1994). The substrates vary and are decomposed granite, quarts, dolomite or dolerite. *Z. cretaceum* is drought deciduous, just as many other *Zygophyllum* species. When leafless or nearly so, its white stems become prominent (Figure 7.46.2.A). Grazing damage is rare and as the rocky terrain and harsh climate of its habitat excludes large scale agriculture, this species is at present not threatened. Flowering period is

from April to September with a peak during August. Mature fruits are found soon after flowering.

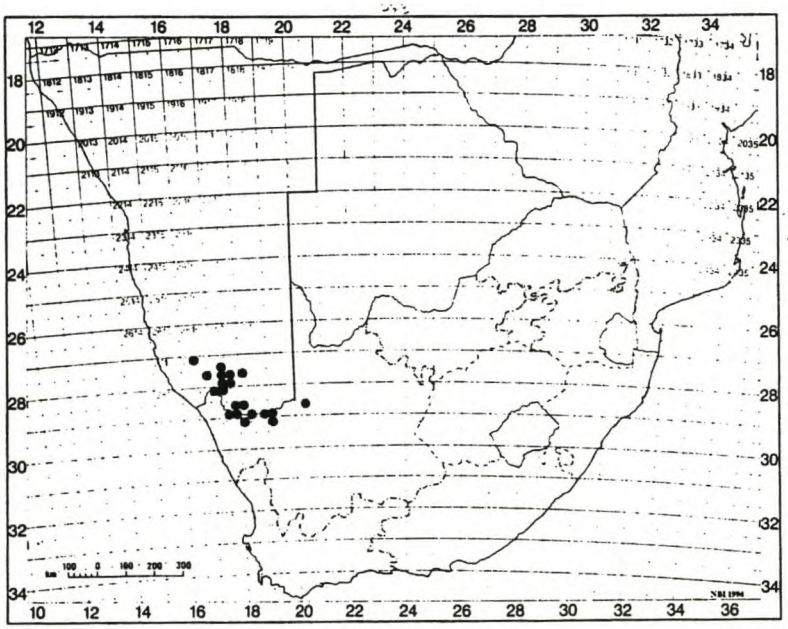


Figure 7.46.3. Geographical distribution of *Z. cretaceum*.

Specimens examined

–2716 (Witputz): 41 M S of Aus, on road to Witputz Police Station (–AB), *De Winter & Giess 6298* (WIND); Between Arimas and Kolke, N of Rosh Pinah (–DB), *Van Zyl 4411* (NBG, PRE, WIND); Between Kolke and Witputz Sud, N of Rosh Pinah (–DB), *Van Zyl 3904* (NBG, PRE).
–2717 (Chamaites): Nuichas, district Bethanien (–AD), *Range 695* (BOL); Hunsberg, Kumdans area near farm Mara (–CB), *Craven 2961* (WIND); Near Zebrakloof base on farm Mara (–CD), *Craven 3327* (WIND); On way to Asbosvlakte on farm Mara (–CD), *Craven 3572* (WIND); At start of trail in Visrivier gorge (–DA), *Van Jaarsveld 8764* (NBG); Naturschutzpark Fischflusscanyon (–DA), *Meyer 30* (WIND); Altdoorn, NE of Ai-Ais (–DC), *Van Zyl 3837* (B, NBG, PRE, S, WIND); Ai-Ais holiday resort

(–DC), *Van Zyl 3832* (NBG, PRE, WIND); 6 km E of Ai-Ais (–DC), *Van Zyl 4358* (NBG, PRE, WIND); *Giess 14567* (PRE, WIND).

–2718 (Grunau): Klein Karas (–CA), *Dinter 4884* (BOL, PRE, SAM); *Örtendahl 484, 589* (PRE).

–2817 (Vioolsdrif): Between the confluence of Dabimub and Boom rivers with the Orange River (–AA), *Van Zyl 4340* (NBG, PRE, WIND); Debe river, at entrance to Helskloof (–AA), *Van Zyl 4501* (NBG, WIND); Near Grootpenseiland, along the N side of the Orange River (–AB), *Van Zyl 4328* (NBG, PRE, WIND); 19 M N of Vioolsdrift (–DB), *Schelpe 217* (BOL); Swartkopmyn, SE of Vioolsdrif (–DC), *Van* Zyl 4488 (NBG, PRE, WIND); SW slopes of Baviaanskop, Settlement Area (–DD), *Le Roux 2879* (NBG).

–2818 (Warmbad): Sperlingsputz (–CA), *Verdoorn & Dyer 1786* (PRE); Farm Witputz 258, quartz hills (–CA), *Giess, Volk & Bleissner 6957* (PRE, WIND); N of Goodhouse, Warmbad district (–CD), *Craven 3840* (WIND); Ramansdrift, district Warmbad (–CD), *Kruger 28* (PRE); Goodhouse (–DD), *Marloth 13241* (PRE).

–2819 (Ariamsvlei): Farm Vellorsdrift, WAR 93, between granites near Orange River (–CB), *Giess, Volk & Bleissner 7056* (WIND); At Pelladrift, 2.5 km S of Orange River (–CC), *Le Roux* 3702 (NBG); *Van Zyl 4319* (NBG, PRE, WIND); Riverbank on Keimas: WAR 99 (–CC), Giess & Muller 12166 (WIND).

–2820 (Kakamas): Aughrabies, Upington district (–CB), *Barnard s.n.* (SAM 32451).

–2918 (Gamoep): 10 km S of Goodhouse towards Concordia (–AA), *Van Zyl 4321* (NBG, PRE, WIND).

–2919 (Pofadder): In empty stand at Pella (–AA), *Van Zyl 4324* (NBG, PRE); Groot Pellaberg (–AA), *Van Jaarsveld & Patterson 6701* (NBG); 5 km N of Pofadder (–AB), *Acocks 14393* (PRE).

Unknown or no precise locality: Tuahab/Imachab, Great Namaqwaland, *Dinter 1022* (Z); Ganus, *Dinter 4234* (B).

7.47 **Zygophyllum foetidum** *Schrad. & Wendl.:* Sertum Hannoveranum..: 1,3 : 17, t. 9 (1795); Willd.: 561 (1799); Pers.: 463 (1806); Thunb.: 543 (1823); DC.: 705 (1824); Don: 771 (1831); Sond.: 364 (1860); Huysst.: 74 (1937); Bond & Goldblatt: 437 (1984). ICONOTYPE: Schrad. & Wendl.: Sertum Hanoveranum..... 1,3 : 17, t. 9 (1795).

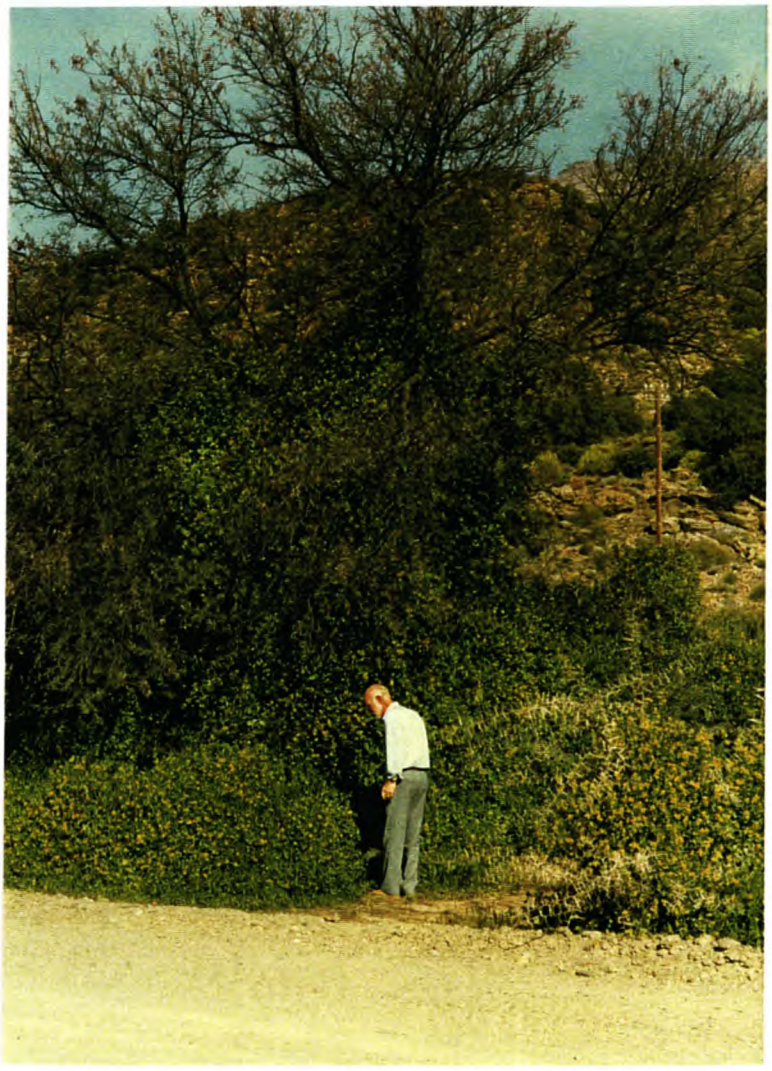
Zygophyllum insuave *Sims*: 372 (1797); Eckl. & Zeyh: 96 (1835). ICONOTYPE - Sims in Curtis's botanical magazine: t. 372 (1797).

Zygophyllum meyeri *Sond.*: 364 (1860); Huysst.: 74 (1937); A.Schreib.: 88 (1963); A.Schreib. in Merxm.: 16 (1966). TYPE: Bei Mierenkasteel, *Drège s.n.* "a" (S! lecto., annotated by Sonder, designated here, SAM!).

Rounded, many-stemmed shrub reaching a height of 1.5 m and a diameter of 2.0 m, or scrambling into and over surrounding vegetation, exceeding 3 m in height and several meters in diameter. *Stems*: old stems grey, usually square in section; young stems smooth, pale green, round or elliptic in cross section, without a flat ventral area or lateral ridges, striate when dry. *Leaves* opposite, petiolate, bifoliolate; rachis apex triangular, green, patent, 2 x 1 mm; petiole adaxially grooved, 6—20 mm long; leaflets glossy, dark green, articulate, asymmetrical, obovate, apex rounded, base oblique, midrib and lateral veins partly visible, 25–43 x 16–30 mm; stipules membranous, reflexed, caducous, triangular, 3 x 2 mm, usually two on ventral side or only one but then notched at apex and only one, sometimes notched, on dorsal side of stems. *Flowers* solitary or two together, axillary. *Pedicel* up to 20 mm long. *Sepals* 5, obovate or ovate, some with membranous margins, margins sometimes ciliate, glabrous, sparsely or densely, white-woolly, persistent, reflexed in fruit, 4–6 x 3–4 mm. *Petals* 5, obovate, apex obtuse, base with a short claw, deep yellow with red or brown, M-shaped markings at base, sometimes unmarked, 15–22 x 7–12 mm. *Nectar disc* fleshy, papillate, regularly 10-angled. *Stamens* 10; filaments terete, 10—12 mm long; staminal scales 10, simple, oblong, upper margins lacerate, bordered with dense, short papillae or sometimes papillate on upper half of ventral surface, 3.0–4.8 x 1.5–2.0 mm, ± 1/3 the length of the filament. *Ovary* spheroid or vaguely 5-lobed; style terete; stigma simple. *Fruit* a droopy, loculicidal capsule; when fresh, subspheroid, slightly longer than wide, green, without ridges or visible sutures, when dry fawn coloured and 5-lobed, each lobe with a broad, bony central ridge that is paler in colour and where splitting will occur, 8–12 x 6–10 mm. *Seed* oblong, 1—5 per locule, 4–5 x 2–3 mm, dark brown with a white aril, testa smooth, glossy, producing brown, structured mucilage with long, spiral inclusions of a uniform width when wet (Figure 7.47.1).

Diagnostic characters

Z. foetidum is recognized by its repulsive smell (hence the specific epithet) which fills the air on a windless day, by its petiolate leaves, by its subspheroid, 5-lobed and ridged, two-toned, fawn coloured fruits with broad and bony ridges. Old stems are sometimes square in cross section. This is an unstable character and not of value



A

B

C

Figure 7.47.1. *Z. foetidum*. A—B, *Van Zyl 4103*; C, *Van Zyl 4547*. A, flower with red markings; B, scrambling habit climbling into trees, reaching a height of 3 m and a diameter of several meters in the Seweweekspoort; C, leafless state during December, near Calvinia.

for identifications. *Z. foetidum* resembles *Z. leptopetalum* in vegetative characters but the petals of the latter are always white and red-veined in contrast to the yellow petals of *Z. foetidum*. *Z. foetidum* is allied to *Z. cretaceum* and *Z. macrocarpon* with regard to vegetative and floral morphology. They all have similar petiolate leaves differing only in size, the leaflets of *Z. macrocarpon* the largest, 35–50 x 30–45 mm in size, *Z. foetidum* following with leaflets of 25–43 x 16–30 mm in size and *Z. cretaceum* the smallest with leaflets of 23–28 x 15–22 mm in size. All are inclined to a rounded, untidy habit, scrambling into and over nearby plants, although this is rarely seen in *Z. leptopetalum* because of grazing damage. *Z. foetidum* and *Z. leptopetalum* have similar subspheroid fruits, which become 5-lobed when dry with broad, bony ridges. Their fruits differ though, those of *Z. leptopetalum* are mono-coloured and those of *Z. foetidum* are two-toned in colour. The fruits of *Z. cretaceum* are small (3.5—5.0 mm in size), 5-lobed, with a thin, disintegrating exocarp, exposing the seeds while the fruits of *Z. macrocarpon* are prismatic and 5-winged. Table 7.10 summarizes the characters of the species in § *Capensia* with petiolate leaves.

Distribution and ecology

Z. foetidum has a large distribution range. It occurs from the Richtersveld in the Northern Cape Province to Grahamstown in the Eastern Cape (Figure 7.47.2). It is found in a vegetation classified as **Succulent Karoo Biome**: Upland Succulent Karoo, Lowland Succulent Karoo and Little Succulent Karoo (Hoffman 1996) and in the Eastern Cape, in **Thicket Biome**: Valley Thicket, Xeric Succulent Thicket and Mesic Succulent Thicket. The Succulent Karoo Biome receives rain during winter months
and the precipitation varies from 50 to 300 mm per annum. Summers are hot and dry. Substrates in the Succulent Karoo Biome vary from decayed granite and gneiss along the west coast and shale in the east. Most collections of *Z. foetidum* were made in this biome. The Thicket Biome also receives rain during the winter months, and the precipitation ranges from 300—800 mm per annum. Substrates include dune sands, lime-rich sandy clays or sandy loam and the vegetation is dominated by low trees, shrubs and vines. Populations consist of scattered individuals, usually

clearly visible in the landscape because of the large size of the plants and abundance of flowers. No grazing damage occur probably because of its usually foul smell. Individuals are found along stream beds, scrambling over shrubs and into larger trees, often forming large entwined masses reaching heights and diameters of several meters (Figure 7.47.1 B). *Z. foetidum* is drought deciduous in response to water stress (Figure 7.47.1.C). Flowering period is from June to December with a peak during spring.

Common names: jakkalspisbos, slymbos.

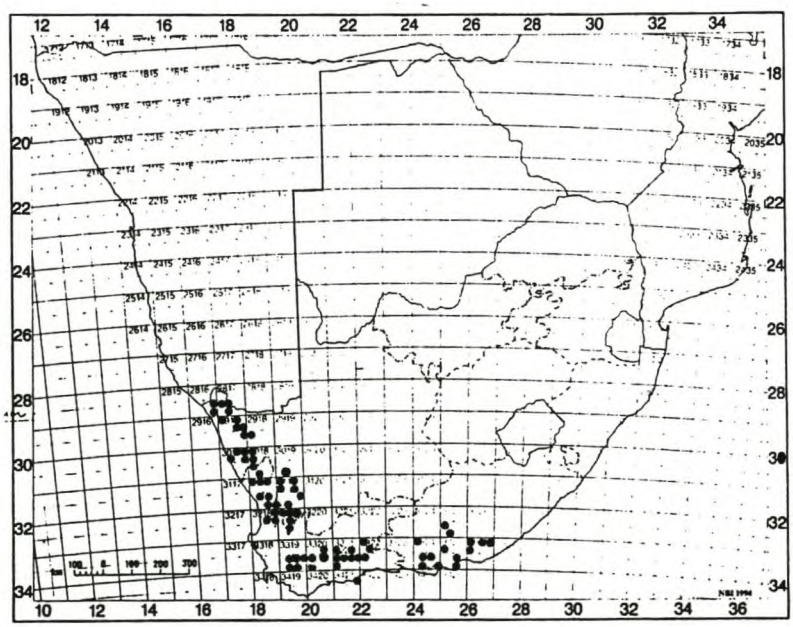


Figure 7.47.2. Geographical distribution of *Z. foetidum*.

Specimens examined

–2816 (Oranjemund): Doornpoortrivier, SW of Khubus, Richtersveld (–DB), *Van Zyl 4061* (BOL, NBG, PRE); Between Port Nolloth and Holgat (–DD), *Schlechter M. (*STE 10876 in NBG).

–2817 (Vioolsdrif): N side of Wildeperderant, Richtersveld (–CA), *Van Zyl 4056* (NBG); 29 M from Eksteensfontein on road to Mt. Stewart, Richtersveld (–CB), *Germishuizen 4587* (PRE); Klein Helskloofmond (–CD), *Venter 8110* (PRE).

–2917 (Springbok): Karuchabpoort, 9 km S of Lekkersing (–AA), *Oliver, Tölken & Venter 772* (NBG); Klipfontein, Steinkopf (–BA), *Herre STE12008* (NBG); Aninaus Pass, W of Steinkopf (–BA), *Van Zyl 3923* (NBG); Bysondersmeid, Steinkopf (–BC), *Herre s.n.(*STE 19057 in NBG); 29 km N of Springbok

on N1 (–BD), *Van Zyl 3823* (NBG, PRE); On hills near O'Kiep (–DB), *Bolus 9404* (BOL); N of O'Kiep (–DB), *Wisura 2252* (NBG); 4 km W of Springbok on road to Kleinzee (–DB), *Le Roux 2738* (BOL); O'Kiep Golf course (–DB), *Rosch & Le Roux 31* (WIND); 1.5 km N of Dincle Copper mine, Nababeep (–DB), *Hilton-Taylor 2097* (NBG).

–2918 (Gamoep): Hester Malan Wild Flower Reserve (–CA), *Rosch & Le Roux 1382* (PRE).

–3017 (Hondeklipbaai): Between Springbok and Hondeklipbaai (–AD), *Van der Merwe 209* (PRE); Toegabsrug, W of Kamieskroon (–BA), *Van Zyl 4095* (NBG, PRE, WIND); Genis Pass, Khamieskroon (–BB), *Jordaan 1222* (NBG); Arkoup, NE of Kamieskroon (–BB), *Van Zyl 3928* (NBG, PRE, WIND); Kamieskroon (–BB), *Thorne s.n. (SAM 48871)*; Brakdam, Namakwaland (–BD), *Compton 17215* (NBG).

–3018 (Kamiesberg): De Kuilen, NE of Kamieskroon (–AA), *Van Zyl 3755* (NBG, PRE); N entrance to Studor's Pass, Garies (–AC), *Van Zyl 4103* (NBG, PRE, S, WIND); Doornhoekpad, NE of Garies (–CA), *Van Zyl 4130* (NBG, PRE, WIND); 15 M N of Bitterfontein (–CA), *Compton, 20574* (NBG); Hills near Garies (–CA), *Thorne s.n. (SAM 48802)*; 5 M from Garies on road to Pofadder (–CD), *Marsh 451* (NBG); N of Bitterfontein on road to Tweevlei (–CD), *Van Zyl 3746* (NBG).

–3019 (Loeriesfontein): 8 km W of Loeriesfontein (–CD), *Hugo 507* (NBG).

–3118 (Vanrhynsdorp): Mierhoofdskasteel, Vanrhynsdorp (–AA), *Barker 6201* (NBG); Kareebergen (–AB), *Schlechter 8232* (BOL, PRE); NE foothills of Kareeberge, Nuwerus (–BA), *Van Zyl 4003* (NBG, PRE); Zandkraal, Vanrhynsdorp (–CB), *Steyn 411* (NBG); Doornrivier bridge, Clanwilliam (–DA), *Johnson 190* (NBG); Aties, Vanrhynsdorp, (–DA), *Hall 4461* (NBG, PRE); Widouw River, Vanrhynsdorp (–DA), *Compton 17314* (NBG); Nardouwkloof, Clanwilliam district, (–DC), *Stokoe s.n. (SAM 63607)*; Bridge between Trawal and Klawer (–DC), *Goldblatt 7055* (PRE); Nardouw road, Clanwilliam (–DD), *Johnson 231* (NBG); Bulshoek barrage, Olifantsrivier, Clanwilliam (–DD), *Maguire 129* (NBG).

–3119 (Calvinia): 5 km N of Nieuwoudtville on way to Loeriesfontein (–AA), *Van Zyl 4121* (NBG, PRE); Brandkop, N of Nieuwoudtville (–AA), *Barker 9643* (NBG); Nieuwoudtville Wild Flower Reserve (–AC), *Perry & Snijman 2164, 2397* (NBG, PRE); Near Waterval, 8 M NE of Nieuwoudtville (–AC), *Lavis s.n. (BOL 19816)*; Vanrhyns Pass (–AC), *Barker 1391* (NBG); Glen Lion, NE of Nieuwoudtville (–AC), *Mauve & Oliver 34* (NBG); Oorlogskloof, Calvinia (–AC), *Powrie 89* (PRE); Nieuwoudtville (–AC), *Van Son s.n. (PRE 36589)*; De Bos, Elandsberge, S of Calvinia (–BA), *Van Zyl 4028* (NBG, PRE, S, WIND); Groottoring, Calvinia (–BC), *Schelpe 8138* (BOL); Top of Botterkloofpas, Calvinia (–CD), *Maguire 1889* (NBG); Base of Botterkloofpas, Calvinia (–CD), *Maguire 180* (NBG); Klipbak, SW of Calvinia (–DA), *Acocks 18874* (PRE); Dry water courses, Noordhoek, Calvinia (–DB), *Hanekom 2360* (PRE).

–3218 (Clanwilliam): Bulshoek, Clanwilliam (–BB), *Leighton 2386* (BOL); Irrigation dam near Clanwilliam (– BB), *Smuts 2002* (PRE); Radyn, N of Clanwilliam (–BB), *Van Zyl 3664* (NBG); Nardouwkloof turn off, N of Clanwilliam (–BB), *Van Zyl 3666* (NBG); Mountains near Clanwilliam (–BB), *Bodkin s.n. (BOL 8932)*; Bokkeveld, Clanwilliam (–BB), *Adamson s.n. (PRE 8096* (PRE); Rondegat, Kanonkop, Clanwilliam (–BD), *Van Zyl 3593* (NBG, PRE, S, WIND); Algeria turn off from N1 (–BD), *Van der Walt s.n. (PRE 58317)*; Rondegat, Olifantsrivier (–BD), *Schlechter 5038* (BOL).

–3219 (Wuppertal): Mertenhof, upper end of Bidouw valley (–AA), *Taylor 11092* (NBG); Uitkykpas, Cederberg (–AA), *Hugo 541* (NBG); Perdefontein, NE of Pakhuispas (–AA), *Van Zyl 3669* (NBG); Vleikraal, E of Klawer (–DA), *Walters 62* (NBG); Uitspanskraal, on N banks of Doornrivier, Calvinia (–AB), *Van Zyl 4220* (NBG); Matjiesrivier, Cederberg (–AD), *Wagener 180* (NBG); Between Reenen and Gerustheid, Ceres Karoo (–BA/AB), *Van Zyl 4210* (NBG); Tuiskloof, Blinkbergpas (–CB), *Boucher 3091* (NBG).

–3225 (Somerset East): 4 M N of Leeuwrivier Post Office, Pearston (–CA/CD), *Acocks 12010* (PRE); Karoo flats, near Pearston (–CA), *Bolus 1780* (BOL).

–3319 (Worcester): Worcester Veld Reserve (–CB), *Van Breda 18* (PRE); Between Mimosa and Moordkuil, S of Worcester (–CD), *Van Zyl 4265* (NBG, PRE, S); Noree, between Worcester and Robertson (–DA), *Bayer s.n.(NBG 97829)*; Koo, Montagu (–DB), *Compton 3927* (BOL, NBG); Madeba, 8 km W of Robertson (–DC), *Hilton-Taylor 1021, 1746* (NBG); Between Hammanshof and first gate to Jonaskop FM tower (–DC), *Boucher 5097* (NBG).

–3320 (Montagu): Anysberg, Ladismith (–BC/DA), *Compton 20338* (NBG); Baden, Montagu (–CA), *Lewis 1699* (SAM); *Compton 18357* (NBG); Koghmanskloof, Montagu (–CC), *Ryecroft 2699* (NBG); *Van Zyl 3649* (NBG); Ashton (–CC), *Ward 5688* (PRE); 1 M E of Montagu (–CC), *Levyns 439* (NBG); Keurkloof, Montagu (–CC), *Van Huyssteen s.n.* (NBG); Montagu (–CC), *Rogers s.n.* (TM 22319); Olifantsberg, Montagu (–CC), *Viviers 428* (NBG); Bonnievale (–CC), *Compton 4355* (BOL); Near Baths, Montagu (–CC), *Page s.n.* (BOL 15658).

–3321 (Ladismith): 3 km E of Vleikraal on road to Seweweekspoort (–AC), *Van Zyl 3614* (NBG, PRE); *Phillips 1406* (SAM); ½ km N of Bosluiskloofpas (–BC), *Leistner 248* (NBG, PRE); Huirsrivierpas, Calitzdorp (–BC/CB), *Gillett 2060* (BOL, NBG); *Van Niekerk 533* (BOL); Bosluiskloof, Prins Albert (–BC), *Levyns 11466* (BOL); Mansshoop, Little Karoo (–CA), *Laidler 190* (NBG); Rooiberg, Ladismith (–CB), *Manson 294* (NBG); N of Rooiberg, Little Karoo (–CB), *Wurts 1244* (NBG); Bosluiskloofpas, half way down (–CC), *Van Zyl 3698* (NBG, PRE); Matjiesvlei turn off, W of Calitsdorp (–CC), *Van Zyl 3695* (NBG); Flats near Gamkapoort dam (–CC), *Van Zyl 3700* (NBG); Hotel garden, Calitsdorp (–DA), *Van Zyl 3618* (NBG, PRE); Bottom of Huisrivierpas (–DA), *Snijman 444* (NBG); Warmbron, Calitzdorp Spa, behind cottages (–DB), *Taylor 10206* (NBG); S slope of Gamkasberg, Calitzdorp (–DB), *Boshoff P237* (NBG).

–3322 (Oudshoorn): Opposite cemetry, Prins Albert (–AA), *Van Zyl 3623* (NBG); Schoemanshoek, N of Oudshoorn (–AD), *Van Zyl 3620* (NBG); Greylands crossing, 10 km W of Oudshoorn (–CA), *Van Zyl 3619* (BOL, NBG, PRE, S).

–3324 (Steytlerville): Mara, NW of Steytlerville (–AA), *Van Zyl 4187* (NBG); Between Mistkraal and Smitskraal (–CB), *Hugo 1435* (NBG, PRE); Droogekloof, 19 miles from Humansdorp (–CD/DC), *Fourcade 5141* (BOL, NBG, PRE); Baviaanskloof (–DA), *Baylis 236* (PRE); 8 M from Patensie to Andrieskraal (–DA), *Thompson 926* (NBG, PRE); Hankey (–DD), *Fourcade 3318* (BOL).

–3325 (Port Elizabeth): Krompoort, Glenconner (–AC), *Henderson 574* (PRE); Addo, Uitenhage (–DA), *Barker 4989* (NBG); Redhouse, Port Elizabeth (–DC), *Paterson 447, 1135* (BOL); Among shrubs at Swartkopsrivier, Uitenhage (–DC), *Ecklon & Zeyer s.n. (SAM 30021)*.

–3326 (Grahamstown): Milford park near Riebeeck East (–AA), *Britten s.n. (BOL 49151)*; Alicedale (–AC), *Cruden 60* (GRA); Pluto's Vale, Grahamstown (–BA), *Britten A4041* (GRA); *Hoole* T4 (GRA); *Britten 5143* (GRA); Half way down Pluto's Vale (–BA), *Van Zyl 4179* (NBG); Bottom of Pluto's Vale (–BA), *Deacon 23* (PRE); Committees, Fish river valley (–BB), *Dyer 2177* (PRE); Glen Boyd, Albany (–BB), *Lindstedt 33* (PRE).

–3421 (Riversdale): Floodplain, Gouritsmond (–BD), *Bohnen 7708* (NBG, PRE).

Unknown or no precise locality: *Ecklon & Zeyher 755* (C); *Ecklon & Zeyher 754* (C), pro. parte.

7.48 **Zygophyllum macrocarpon** *Retief* in Bothalia 17,2 : 189—190 (1987).

TYPE - Northern Cape: Main ridge SE of beacon and up to summit of Kodaspiek, Richtersveld, *Oliver, Tölken & Venter 417* (PRE!, holo, K, MO).

Erect or sprawling, many-stemmed shrub reaching a height of 1.5 m and a diameter of 1.0 m, resprouting from a woody base. *Stems*: old stems gray, round in cross section, hollow, with striate, flaky bark; young stems smooth, glabrous or rarely covered with short, sparse hairs, light green, round in cross section, without any ridges. *Leaves* opposite, petiolate, bifoliolate; rachis apex triangular, membranous, reflexed, 5 x 2 mm; petiole adaxially grooved, 3—10 mm long; leaflets glossy, dark green, thin textured, articulate, asymmetrical, obovate, 35–50 (90) x 30–45 (80) mm, apex rounded, base oblique; stipules membranous, reflexed, caducous, triangular, one on ventral and one on dorsal side of stems, 6 x 4–6 mm. *Flowers* up to 9 together, axillary. *Pedicel* 20—25 mm long, elongating in fruiting stage to 40 mm. *Sepals* 5, oblong or ovate, glabrous or margins sometimes ciliate, 7–13 x 4 mm. *Petals* 5, obovate, apex obtuse, emarginate, undulate, base with a short claw, deep yellow with red or brown, M-shaped markings at base, 18–23 x 11–14 mm. *Nectar disc* fleshy, papillate, regularly 10-angled. *Stamens* 10; filaments terete, 9—10 mm long; staminal scales 10, simple, oblong, margins with long lacerations, bordered with short, dense, curly papillae, 3–4 x 1.5–2 mm, ± 1/3 the length of the filament. *Ovary* oblong, 5-lobed; style terete; stigma simple. *Fruit* a drooping, prismatoid, 5-winged, loculicidal capsule, 25–43 x 15–20 mm in size, with a narrow central body and 5 mm wide wings. *Seed* oblong, 10—16 per locule, 4–5 x 2–3 mm, dark brown with a white aril, testa glossy, smooth, producing pale, straw-coloured, structured mucilage with long spiral inclusions of a uniform width when wet (Figure 7.48.1).

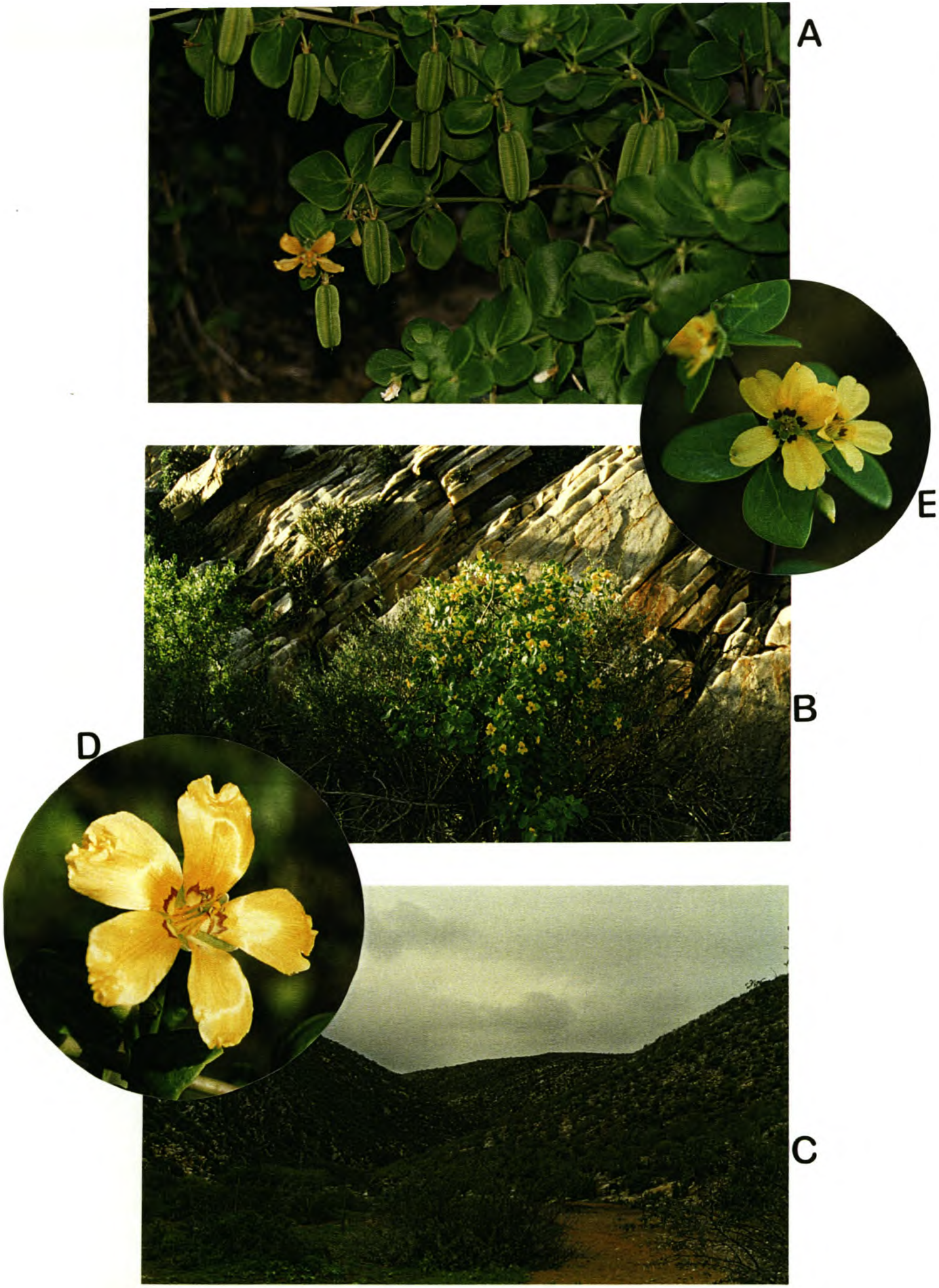


Figure 7.48.1. *Z. macrocarpon*. A—D, *Van Zyl 4040*; E, *Van Zyl 4059*. A, fruiting branch with large, glossy, leaflets and prismatoid, 5-winged fruits; B, habit at base of cliffs near Kouefontein, Richtersveld; C, partially shaded, narrow, east-west running valley, the preferred habitat of this species, Kouefontein, Richtersveld; D—E, variation in petal markings.

Diagnostic characters and affinities

Z. macrocarpon is recognized by its large (25–43 x 15–20 mm in size), prismatoid, 5-winged fruits (hence the specific epithet), with wings of 5 mm in width and by its hollow stems. Hollow stems is a unique character for the southern African species of *Zygophyllum*. *Z. macrocarpon* is allied to *Z. foetidum, Z. cretaceum* and *Z. leptopetalum* with regard to vegetative morphology. They all have similar petiolate leaves differing only in size. The leaflets of *Z. macrocarpon* are by far the largest, 35–50 x 30–45 mm in size, *Z. foetidum* following with leaflets of 25–43 x 16–30 mm, *Z. cretaceum* with leaflets of 23–28 x 15–22 mm and *Z. leptopetalum* with the smallest leaflets of 17–25 x 10–17 mm in size. *Z. leptopetalum* differs in having white, red-veined flowers in contrast to the yellow flowers of the other three species. *Z. foetidum and Z. leptopetalum* have small, ± spherical fruits, very different from the large, prismatoid 5-winged fruits of *Z. macrocarpon.* Within the southern African species of *Zygophyllum,* the fruits of *Z. macrocarpon* are almost the largest, after those of *Z. morgsana* which are 26–40 x 26–40 mm in size and with only four, 10—15 mm wide, reticulate-veined wings. Table 7.10 summarizes the characters of the species in § *Capensia* with petiolate leaves.

Geographical distribution and ecology

Z. macrocarpon has a limited distribution in the lower Orange River basin. In Namibia it occurs on Udabib and Aurus mountains and near Rosh Pinah and in the Northern Cape it occurs in Helskloof and near Lekkersing (Figure 7.48.2). In Namibia it occurs in a vegetation classified as **Nama Karoo Biome** and **Succulent Karoo Biome** (Irish 1994). In the Northern Cape it occurs in a vegetation classified as Upland Succulent Karoo (Hoffman 1996), receiving rains during winter with a precipitation ranging from 150 to 300 mm per year. The substrate is decayed granite and gneiss. *Z. macrocarpon* prefers southern aspects in steep, partially shady, east-west running valleys where the prevailing microhabitat is cooler and with more moisture than in the typical surroundings (Figure 7.48.1.C). It usually occurs at the base of cliffs or near rocky projections, where it is shaded from insolation for some of the daylight hours (Figure 7.48.1.B). The large size of leaflets and its thin

texture (not succulent at all) prevents this species from invading the typical habitat of the Richtersveld. Grazing damage appeared minimal. Like other species of *Zygophyllum*, *Z. macrocarpon* is drought deciduous, partially or completely shedding leaves in response to water stress. During this leafless stage, *Z. macrocarpon* is identified by its hollow stems. Populations are few and small. However, each shrub bears plenty of fruits and each of its 5 loculi are 10–16 seeded, thus producing large numbers of seeds, which probably ensures the continuation of this species.

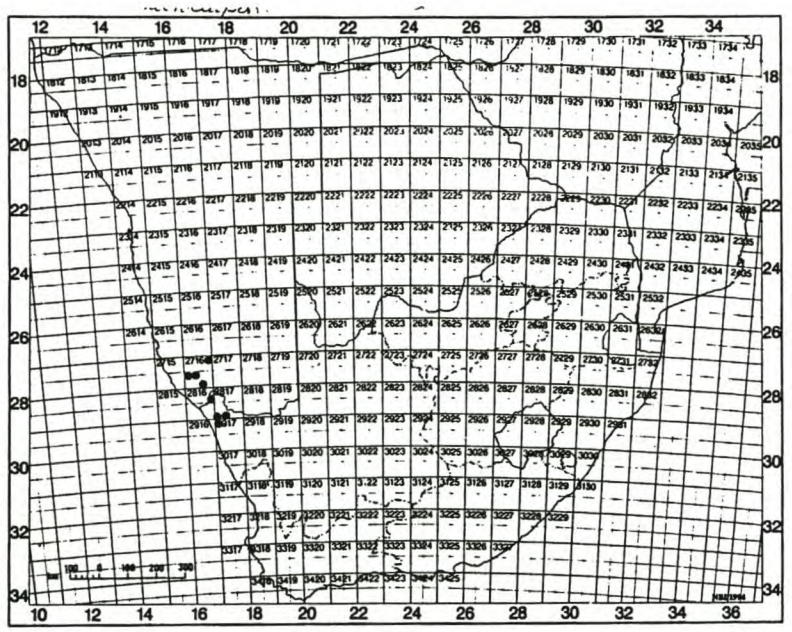


Figure 7.48.2. Geographical distribution of *Z. macrocarpon*.

Specimens examined

–2716 (Witputz): S slopes of Udabib mountains (–BB), *Muller 799* (WIND); Aurus mountain (–CA), *Muller 736* (WIND); Around the beacon on Aurus mountain, Sperrgebiet (–CB), *Oliver 10135* (NBG, PRE); Zebrafontein 87, N of Rosh Pinah (–DC), *Van Zyl 4347* (B, BOL, NBG, S, WIND); SE of mountain on Spitskop LU111 (–DC), *Giess & Muller 14408* (WIND); At cliffs in deep kloof on Spitskop LU111 (–DC), *Giess 13045* (PRE, WIND).

–2816 (Oranjemund): Near top of Helskloof, Richtersveld (–BD), *Van Zyl 3920* (B, BOL, NBG, S, WIND); Head of Helskloof, Hottentotparadysberg (–BD), *Thompson & Le Roux 121* (NBG).

–2817 (Vioolsdrif): Main ridge SE of beacon and up to summit of Kodaspiek, Richtersveld (–AA), *Oliver, Tölken & Venter 417* (K, MO, PRE); Narrow kloof near Skouerfontein, Richtersveld (–CC), *Van Zyl 4059* (NBG, PRE); W of Kouefontein, Richtersveld (–CD), *Van Zyl 4040* (BOL, NBG, PRE, WIND).

–2917 (Springbok): ± 12 km S of Lekkersing, Richtersveld (–AA), *Van Zyl 3922* (NBG, PRE), *Van Zyl 4132* (NBG).

7.49 Zygophyllum maculatum *Ait.* in Hortus Kewensis 2: 60 (1789); Willd.: 561 (1799); Pers.: 463 (1806); DC.: 705 (1824); Don: 771 (1831); Sond.: 361 (1860); Huysst.: 76 (1937). TYPE - Native of the Cape of Good Hope. Introd. 1782. (BM!, holo.).

Erect, many-stemmed shrub, reaching a height of 0.8 m and a diameter of 0.8 m, usually much shorter due to excessive grazing. *Stems*: old stems glabrous, bark dark gray, stringy, flaky; young stems round in cross section, prominently striate, usually with dense, short and straight hairs in the striae, rarely glabrous. *Leaves* opposite, petiolate, bifoliolate, usually covered with short, sparse, straight hairs when young, glabrous with age; rachis apex triangular, reflexed, 0.5 x 0.5 mm; petiole adaxially grooved, 1—2 mm long; leaflets articulate, linear or narrowly obovate with a visible midrib, apex rounded, mucronate, grooved on abaxial side, margins recurved, base cuneate, 6–13 x 1.5–2.0 mm; stipules triangular, membranous, caducous, one on ventral side, apex sometimes shallowly notched and one on dorsal side of stems, 1 x 1 mm. *Flowers* solitary, axillary. *Pedicel* 10—15 mm long. *Sepals* 5, obovate or ovate, apex sometimes ciliate, 4–5 x 2.5–3 mm. *Petals* 5, widely obovate or subrotund, 11–13 x 6–10 mm, apex round, base with a short claw, bright yellow with red or maroon blotches at base which are also visible on the reverse side. *Nectar disc* fleshy, papillate, regularly 10-angled. *Stamens* 10; filaments terete, 5—6 mm long; staminal scales 10, simple, obovate, apex truncate or rounded, upper margins with long lacerations, ventral surface bordered with papillae of uneven length, 3–4 x 1.5–2 mm, ± 1/2 as long as filament. *Ovary* oblong, 5-lobed; style terete, stigma simple. *Fruit* an oblong, 5-lobed, loculicidal capsule, each lobe with a central ridge where splitting will occur, 12–13 x 7–8 mm. *Seed* oblong, 1—3 per locule, 4 x 2 mm, brown with a white aril, testa smooth, glossy, producing structured mucilage with long spiral inclusions of a uniform width when wet (Figure 7.49.1).

Diagnostic characters and affinities

Z. maculatum is distinguished by its young stems which are round in cross section and prominently striate with hairs present within the strias (Figure 7.49.1.A–D), by its

Figure 7.49.1. *Z. maculatum, Van Zyl 4201*. A, twig with prominently striate stems and a front-view of flower; B, twig with striate stems, leaves and a side-view of flower; C, back-view of flower illustrating markings visible on reverse side; D, mature, half-open fruit; E, slightly grazed habit in Skitterykloof, Ceres Karoo.

petiolate leaves with linear or narrowly obovate, abaxially grooved leaflets, by its yellow flowers with staminal scales bordered with papillae and a filament to scale ratio of 2 : 1. *Z. maculatum* resembles *Z. leptopetalum* and *Z. pubescens* with regard to striate, hairy stems, but differs with regard to leaf and flower morphology. The leaflets of *Z. leptopetalum* are widely obovate, flat and asymmetric, its petals are white and red-veined, its staminal scales are bordered with papillae and its filament to scale ratio is 5 : 4. The leaflets of *Z. pubescens* are also obovate with flat laminas, its staminal scales are without a border of papillae and it has a filament to scale ratio of 3 : 1. With regard to leaflet shape, *Z. maculatum* resembles *Z. spinosum*, *Z. pygmaeum* and *Z. rogersii* which have similar, abaxially grooved, linear leaflets, but the leaves of the latter three species are sessile. These four species mentioned last have similar 5-lobed and ridged fruits. Table 7.10 summarizes the characters of the species in § *Capensia* with petiolate leaves.

Distribution and ecology

Z. maculatum is found on the lower slopes of the mountains to the west and south of the Tankwa Karoo and on the lower lying areas around Laingsburg and Matjiesfontein in the Great Karoo (Figure 7.49.2). It occurs in a vegetation classified as **Succulent Karoo Biome**: Upland Succulent Karoo and Lowland Succulent Karoo (Hoffman 1996). Rain occurs during winter months and summers are extremely dry and hot. Substrates are lime-rich and derived from Karoo Sequence shale and sandstone. The vegetation is dominated by succulents from the Mesembryanthemaceae. Populations consist of scattered individuals over large areas. Grazing damage is excessive and undamaged, normal looking individuals of this species, with flowers and fruits, are only found in spots inaccessible to grazers. Grazing damage is also evident on herbarium specimens. *Z. maculatum* is a valuable stock plant, but suffers from over exploitation and needs to be protected from total eradication (Van Breda & Barnard, no date). Flowering and fruiting periods are from May to October.
Common name: Lanternbos.

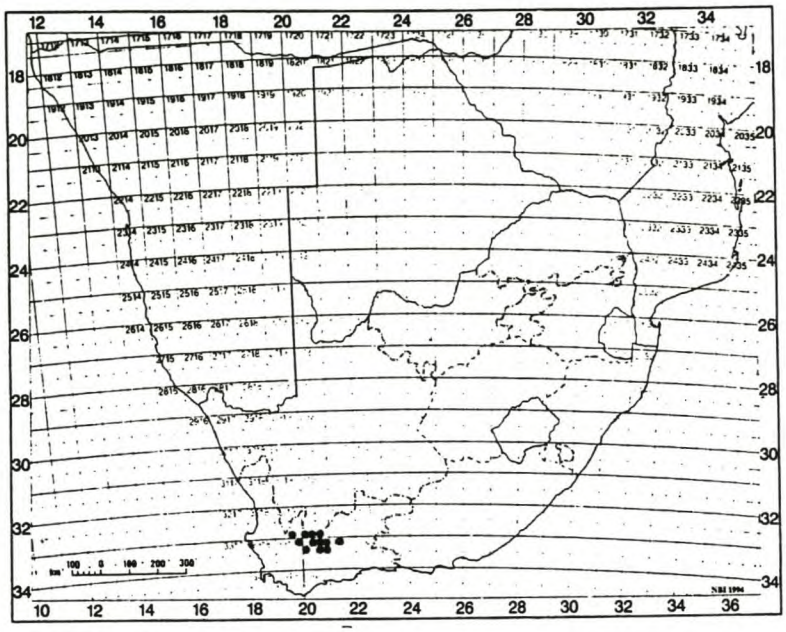


Figure 7.49.2. Geographical distribution of *Z. maculatum*.

Specimens examined

–3219 (Wuppertal): Base of Skitterykloof, Ceres Karoo (–DC), *Van Zyl 4201* (NBG, PRE).

–3220 (Sutherland): Base of Thyshoogte (–CC), *Van Zyl 3738* (NBG); Oude Muur, SW slopes of Koedoesberge, Sutherland (–CC), *Hugo 401* (NBG); Between Bloemfontein and Windheuwel, S of Sutherland (–CD), *Van Zyl 3737* (NBG); Near Snydersberg, Laingsburg (–CD), *Van Breda 2040* (PRE); 55 km S of Sutherland (–DC), *Thompson 3009* (NBG).

–3319 (Worcester): Doringrivier crossing between Ceres and Sutherland (–BB), *Van Zyl 4027* (NBG, PRE); *Van Zyl 4432* (BOL, GRA, NBG, PRE, S).

–3320 (Montagu): Palmietfontein, NW of Matjiesrivier (–AB), *Van Zyl 4157* (NBG); Patatsrivier, NW of Matjiesfontein (–AB), *Van Zyl 4156* (NBG); Near Jan de Boers Stasie (–AC), *Van Breda 4613* (PRE); Karoo Garden, Whitehill, Laingsburg (–BA), *Compton 2914* (BOL), *Compton 10885* (NBG), *Compton 14593* (NBG); Near Matjiesfontein, on gravel road to Ceres (–BA), *Van Zyl 4158* (NBG); SW foothills of Ghaapkop, near Matjiesfontein (–BA), *Van Zyl 3978* (NG); At foot of hill W of Laingsburg (–BB), *Smith s.n.* (PRE 46003); Near Witteberg turnoff, S of Laingsburg (–BB), *Van Zyl 3980* (NBG); Between Eselsfontein and Varsbokkraal, S of Laingsburg (–BC), *Van Zyl 3982* (NBG); Klein Rietfontein, 14 km S of Laingsburg (–BD), *Van Zyl 3719* (NBG).

–3321 (Ladismith): Nuwejaarskraal, NE of Laingsburg (–AB), *Van Zyl 3721* (NBG).

7.50 Zygophyllum schreiberanum *Merxm. & Giess* in Mitteilungen der Botanischen Staatssammlung München 2 : 447 (1974). TYPE - Namibia: W aspect of hill 8 km N of Rosh Pinah, *Merxmüller & Giess 28510* (M, holo, PRE!, WIND!).

Erect, many-stemmed shrub, reaching a height of 0.8 m and a diameter of 1.0 m. *Stems*: old stems nude, bark rough, black or dark gray, cracked; young stems greenish or reddish-brown, smooth, leafy, densely covered with short, straight hairs, rhombic in cross section and without any ridges, becoming somewhat striate when dry. *Leaves* opposite, petiolate, trifoliolate; typical rachis apex absent, replaced by the third leaflet; petiole terete, finely indented or adaxially grooved, 4–15 x 1–2 mm; leaflets terete, not articulate, khaki-green, in juvenile stage covered with dense, short, straight hairs, apex mucronate, glabrescent or glabrous with age, becoming black when dry, 10.0–20.0 x 1.5–2.0 mm; stipules leaflike, on ventral side of stems alternately single or biparted on consecutive nodes and on dorsal side always single, base semi-permanent, 3–11 x 1–2 mm. *Flowers* 1—2 together, axillary. *Pedicel* 10—25 mm long, elongating in the fruiting stage to 30 mm. *Sepals* 5, adnate at base, ovate, apex acute, some with membranous margins, 5.0–6.0 x 3.0–3.5 mm. *Petals* 5, elliptic or obovate, apex acute or rounded, often emarginate, base with a short claw, lime yellow or dark yellow, variously marked at base with red M- or U-shaped blotches, 13–15 x 5–6 mm. *Nectar disc* fleshy, papillate, regularly 10-angled. *Stamens* 10; filaments terete, 5—6 mm long; staminal scales 10, simple, oblong or obovate, margins with long lacerations, upper half of ventral surface bordered with papillae of unequal length, 3–4 x 2 mm, ± 2/3 the length of the filament. *Ovary* ovoid, 5-lobed; style terete; stigma simple. *Fruit* a drooping, subspheroid, 5-lobed, loculicidal capsule with a retuse apex, each lobe with a narrow, central ridge where splitting will occur, 7–8 x 7–8 mm, becoming black when dry. *Seed* oblong, 1–2 per locule, 4 x 1.8 mm, dark brown with a white aril, testa glossy, smooth, producing yellowish, structured mucilage with long, spiral inclusions of a uniform width when wet (Figure 7.50.1).

B

C

D

Figure 7.50.1. *Z. schreiberanum.* A,B, D, *Van Zyl 4062*; C, *Van Zyl 4134*. A, twig with trifoliolate leaves and a flower in side-view; B, leafy twig with a flower in front-view; C, leafy branches with immature fruits; D, habitat on Cornellskop in the Richtersveld.

Diagnostic characters and affinities

Z. schreiberanum is distinguished by its petiolate, trifoliolate leaves with terete leaflets (Figure 7.50.1.A–B) and similar leaflike stipules. Trifoliolate leaves and leaflike stipules are unique for *Zygophyllum* in southern Africa. It is also distinguished by its young stems that are hairy and rhombic in cross section. With regard to hairy stems, it resembles *Z. leptopetalum*, *Z. pubescens* and *Z. maculatum* although it lacks their stem striations and has a differently shaped, rhombic stem in cross section. The fruits of *Z. schreiberanum* become black when dry and resemble those of *Z. incrustatum* which are similarly shaped, and also turn black when dry. With regard to floral morphology *Z. schreiberanum* resembles those species with papillate bordered staminal scales, *Z. cretaceum*, *Z. foetidum, Z. macropteron* and *Z. maculatum*. Originally placed in § *Capensia* by Merxmüller *et al.* (1974), *Z. schreiberanum* remains isolated within the section and with regard to leaf and stipule morphology it has no close affinities. Table 7.10 summarizes the characters of the species in § *Capensia* with petiolate leaves. The specific epithet *schreiberanum* commemorates Annelis Schreiber, the author of Die Gatting *Zygophyllum* L. in Südwestafrika in Mitteilungen aus der Botanische Staatssammlung München 5: 49–114 (1963).

Distribution and ecology

Z. schreiberanum has a limited distribution in the lower Orange River basin where it occurs in the Rosh Pinah district, Namibia as well as in the Northern Cape, on Cornellskop in the Richtersveld (Figure 7.50.2). In Namibia it occurs in a vegetation classified as **Succulent Karoo Biome** (Irish, 1994) whereas in South Arica, the classification of the vegetation in which it occurs is further refined as Lowland Succulent Karoo (Hoffman 1996). The Lowland Succulent Karoo occurs below the escarpment at low altitudes and represents an extremely arid vegetation type. The precipitation is low and ranges from 50 to 200 mm per year, occurring during winter. Summers are extremely arid and hot. Substrates are rich soils derived from decaying granite and gneiss, whereas sands are predominant closer to the coast. No grazing damage occurs. *Z. schreiberanum* is drought deciduous in response to

water stress and appears nearly leafless during December. Ants and honey bees are active on *Z. schreiberanum* during the flowering season, probably serving as pollinators. Flowering and fruiting periods are from June to August. This species usually occurs on rocky slopes, on southern or south-eastern aspects and seems to avoid valley floors or wide plains. A single population was described as large, whereas others consist of occasional, scattered individuals including seedlings and young plants. Although *Z. schreiberanum* occurs within the restricted Mining Areas where its habitat is indirectly protected, its very limited distribution, with few recorded populations and usually of a small size, makes this species vulnerable.

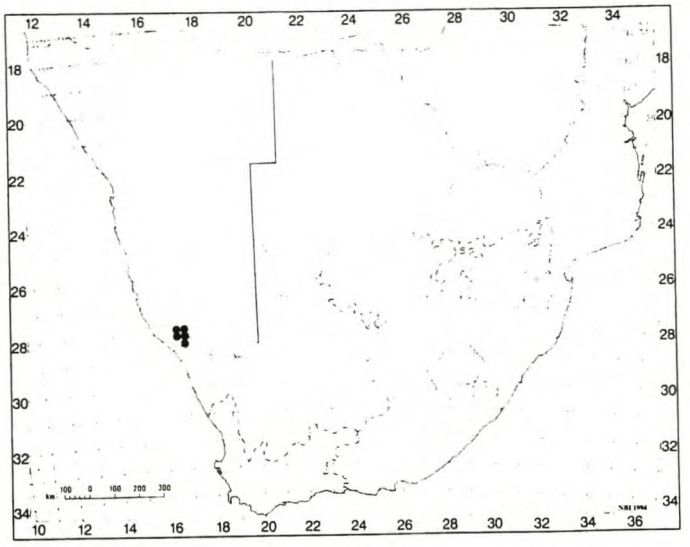


Figure 7.50.2. Geographical distribution of *Z. schreiberanum*.

Specimens examined

–2716 (Witputz): W aspect of hill on Spitskop: LU 111 (–DC), *Giess & Muller 14390* (PRE, WIND); W aspect of hill, 8 km N of Rosh Pinah (–DC), *Merxmüller & Giess 28510* (PRE, WIND); *Van Zyl 3897* (BOL, NBG, PRE); Namuskluft, E of Rosh Pinah (–DD), *Van Zyl 4386* (NBG).

–2816 (Oranjemund): 15 km S of Obib Wasser on mountain side (–BA), *Giess 12997* (PRE, WIND); 1 M into the valley at Lorelei Copper Mine (Kahanstal) (–BB), *Giess 10206* (WIND); Kahanstal (–BB), *Dinter 8068* (BOL, PRE); *Merxmüller & Giess 3338* (PRE, WIND); Cornellskop, W of Khubus, Richtersveld (–BD), *Van Zyl 4062* (BOL, NBG, PRE, WIND); *Van Zyl 4134* (NBG, WIND); *Van Zyl 4502* (NBG, PRE).

7.51 Zygophyllum leptopetalum *Sond.*: 363 (1860); Huysst.: 73 (1937); A.Schreib.: 82 (1963); A.Schreib. in Merxm. 17 (1966). TYPE - Northern Cape: Silverfontein, 2000–3000 f. *Drège s.n.* (S!, lecto., designated here, KIEL, P! S, SAM!,).

Zygophyllum laxum *Engl.*: 735 (1915) nom. nud.

Rounded, multi-stemmed shrub, usually reaching a height of 1 m and a diameter of 1 m, exceptionally attaining a height and diameter of more than 2 m, usually smaller due to heavy grazing. *Stems*: old stems dark grey, square or round in cross section, nude; young stems square but with rounded angles, often completely striate, sometimes covered with short, sparse, straight hairs. *Leaves* opposite, bifoliolate, petiolate; petiole adaxially grooved, 7—10 mm long; rachis apex green, triangular, reflexed, 2 x 1 mm; leaflets articulate, asymmetrical, green or glaucous, midrib partly visible, obovate, lamina flat, 17–25 x 10–17 mm, apex rounded or acute, base oblique or rounded; stipules membranous, reflexed, triangular, usually one, rarely two ventrally, only one dorsally on stem, 3 x 2 mm, caducous. *Flowers* solitary or two together, axillary. *Pedicel* 5—18 mm long. *Sepals* 5, obovate or ovate, some membranous margined, glabrous or woolly on dorsal surface, persistent, reflexed with age, 3–4 x 2–3 mm. *Petals* 5, all patent or posterior two reflexed and anterior three extended, obovate or widely obovate, 8–12 x 4–6 mm, apex rounded, often emarginate, base with a short claw, white with reddish-maroon veins and blotched at base with maroon or brown on all or only some of the petals, sometimes unmarked. *Nectar disc* fleshy, papillate, regularly 10-angled. *Stamens* 10; filaments terete, 4.5—5.5 mm long; staminal scales 10, simple, oblong, margins lacerate and most of ventral and some of the dorsal surface covered with long, curly papillae, 3.5–4.5 x 1.5–2 mm, ± 4/5 the length of the filament. *Ovary* spheroid, with faint sutures visible; style terete; stigma simple. *Fruit* a drooping, loculicidal capsule; when fresh oblong, slightly longer than wide or subspheroid, vaguely 5-lobed with sutures visible or absent; when dry uniformly honey-brown in colour and 5-lobed, each lobe with a broad, central ridge where splitting will occur, 7–13 x 7–12 mm. *Seed* oblong, 1—2 per locule, 5.5 x 2.3 mm, dark brown with a white aril, testa smooth, glossy, producing structured, whitish-yellow mucilage with long, spiral inclusions of a uniform width when wet (Figure 7.51.1).

Figure 7.51.1. Z. leptopetalum. A, *Van Zyl 3955*; B,C,E, *Van Zyl 4349*; D, *Van Zyl 4108*. A, twig with red-veined, white flower and immature fruits; B, side-view of flower illustrating the reflexed, posterior petals and extended, anterior petals; C, twig with leaves and immature fruits; D, large habit of more than 2 m in height and in diameter, near Vanrhynsdorp; E, grazed shrub covered in white flowers.

Diagnostic characters and affinities

Z. leptopetalum is distinguished by its white flowers with maroon veins (Figure 7.51.1.A), by its staminal scales with lacerate margins and ventrally densely covered with curly papillae and by its filament to scale ratio of 5 : 4. *Z. leptopetalum* resembles *Z. spitskopense* and *Z. sessilifolium* with regard to their white, red-veined flowers, but with regard to leaf morphology differs from them in having petiolate leaves. With regard to habit *Z. leptopetalum* resembles *Z. foetidum,* a similar multi-stemmed, rounded shrub able to scramble into nearby vegetation and so reaching large sizes. The petiolate leaves with asymmetrical obovate, flat leaflets of *Z. leptopetalum* (Figure 7.51.1.C), are similar to those of *Z. foetidum, Z. cretaceum* and *Z. marcrocarpon* but differ in dimensions. Those of *Z. macrocarpon* are the largest, 27–60 x 24–58 mm in size and those of *Z. leptopetalum* the smallest, 17–25 x 10–17 mm in size. *Z. leptopetalum* and *Z. foetidum* have similar subspherical, 5-lobed fruits with broad, bony ridges and are 10 x 10 mm in size. *Z. macrocarpon* has large, prismatic, 5-winged fruits of 45 x 18 mm in size, whereas the fruits of *Z. cretaceum* are small, subspheroid, 3.5—5.0 mm in size and distinguished by a thin, disintegrating exocarp that exposes the seeds. Table 7.10 summarizes the characters of the species in § *Capensia* with petiolate leaves.

Distribution and ecology

Z. leptopetalum occurs in southern Namibia, the Richtersveld and Namaqualand, from Witputz in the north to as far south as Vanrhynsdorp (Figure 7.51.2). In Namibia it occurs in a vegetation classified as **Succulent Karoo Biome** (Irish 1994), with rain falling during winter months. Summers are extremely arid and hot. In South Africa it occurs in a vegetation classified as **Succulent Karoo Biome**: Upland Succulent Karoo and Lowland Succulent Karoo (Hoffman 1996). The substrates are derived from decayed granite and gneiss as well as sandstone and shale. The vegetation is dominated by dwarf, succulent shrubs belonging to the Mesembryanthemaceae. Low, winter rains with a precipitation ranging from 50—

300 mm per year is received. Summers, with extreme summer aridity and temperatures of 40° C is the norm.

Populations consist of scattered individuals over large areas. *Z. leptopetalum* is palatable and popular with grazers, resulting in extensive grazing damage. This is also reflected on herbarium specimens. Seedlings and young plants are rare. When protected from grazers and under favourable conditions, *Z. leptopetalum* reaches heights and diameters of 2 m or more, scrambling into nearby trees (Figure 7.51.1.D) or leaning against rocks, thus resembling *Z. foetidum*. This is probably the habit *Z. leptopetalum* usually acquires in the absence of grazing and is quite different from the misleading height of 30—40 cm as recorded on many herbarium sheets. The smaller dimensions probably reflect on the grazing pressure experienced by this species. Flowering and fruiting periods are from May to September. *Z. leptopetalum* is widespread with many known populations and is probably not threatened at present.

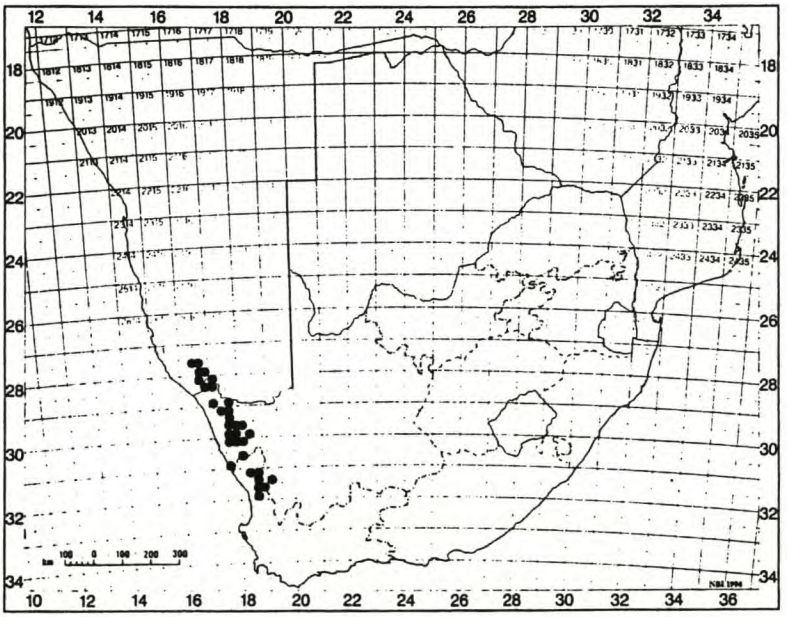


Figure 7.51.2. Geographical distribution of *Z. leptopetalum.*

Specimens examined

–2716(Witputz): Aurus Mountains in Sperrgebiet (–CB), *Oliver 10129* (NBG); Sud Witputz 31, N of Rosh Pinah (–DA), *Van Zyl 3901* (B, NBG, PRE, WIND), *Merxmüller & Giess 3217* (PRE, WIND); Spitskop, LU 111 (–DC), *Giess 14657* (PRE, WIND); Zebrafontein, N of Rosh Pinah (–DC), *Botha*

3343 (PRE); W of Rosh Pinah (–DD), *Craven 1176* (WIND); Namuskluft, LU 88, on way to Kokerboomkloof (–DD), *Giess & Muller 14358* (WIND).

–2816 (Oranjemund): Obibfontein, Diamond area no. 1 (–BA), *Owen-Smith 1140* (WIND), *Range 574* (PRE); 1 m from rivier, unterhalb Obibwasser (–BA), *Giess 13011* (WIND); Kahanstal, (–BB), *Dinter 8070* (BOL); Grasvlakte, turn off to Helskloof, Richtersveld (–BD), *Van Zyl 3917* (NBG, PRE, WIND).

–2817 (Vioolsdrif): Kodaspiek, Richtersveld (–AA), *Oliver, Tölken & Venter 477* (NBG, PRE); SW of Kodaspiek, Richtersveld (–AA), *Thompson & Le Roux 226* (NBG, PRE); Rosyntjiesberg, Richtersveld (–AC), *Venter 8158* (PRE); Large kloof on N side of Lelieshoek (–AC), *Oliver, Tölken & Venter 311* (NBG, PRE); Die Plate, S of Eksteensfontein (–CC), *Van Zyl 4045* (NBG); Narrow kloof near Skouerfontein (–CC*), Van Zyl 4057* (NBG); Mountain N of Bleskop, near Blesberg Mine (–DC), *Le Roux 2893* (NBG).

–2917 (Springbok): Between Boesmanpunt and Sabiboomrante, Richtersveld (–AB), *Van Zyl 4039* (NBG, PRE); Aninauspas, W of Steinkopf (–BA), *Van Zyl 3924* (NBG), *Van Zyl 4035* (NBG, PRE, WIND); 2 km from Bulletrap to Nigramoep (–BC), *Van Wyk 6302* (PRE); Spektakel, Namaqualand (–DA), *Barker 1351* (NBG); On Copperberg, Namaqualand (–DB), *Pillans 6244* (BOL); 6 M on road to Steinkopf from Springbok (–DB), *Verdoorn & Dyer 1816* (PRE); 27 M S of Springbok (–DB), *Barker 6315* (BOL, NBG); N slopes of Rooiberg above Buffelsrivier (–DC), *Hilton-Taylor 2136* (NBG); Droëdap, Namaqualand (–DD), *Compton 11453* (NBG).

–2918 (Gamoep): S side of Khouries mountain (–AC), *Van der Westhuizen 96/80* (PRE); Hester Malan Veldblomreservaat, Springbok (–CA), *Rösch & Le Roux 343* (PRE).

–3017 (Hondeklipbaai): Between Komaggas and Soebatsfontein (–BA), *Maguire 409* (NBG); Killian's Pass, W of Kamieskroon (–BA), *Van Zyl 4097* (NBG); SE of Toegabsrug, Kamieskroon (–BA), *Van Zyl 4096* (NBG, PRE); Arkoep, NE of Kamieskroon (–BB), *Van Zyl 3929* (NBG, PRE, WIND); 27 M S of Springbok (–BB), *Lewis 2936* (PRE).

–3018 (Kamiesberg): Pedroskloof, 18 km E of Kamieskroon (–AA), *Hilton-Taylor 2216* (NBG); 15 M N of Bitterfontein (–CA), *Compton 20577* (NBG);

–3118 (Vanrhynsdorp): NW side of Kareeberge, Nuwerus (–AB), *Van Zyl 4005* (NBG, PRE); Nieuwerust, Vanrhynsdorp (–AB), *Barker 3728, 7433* (NBG); 1 km on Kliprand turn off from N7 (–BA), *Van Zyl 4002* (NBG, PRE); 31 km N of Vanrhynsdorp at a bridge along N7 (–BC), *Van Zyl 3999* (B, NBG, PRE, WIND); Knechtsvlakte, Vanrhynsdorp (–BC), *Compton 11132* (NBG), Esterhuysen 5300 (BOL); 32 km N of Vanrhynsdorp (–BC), *Van Zyl 3955* (NBG, PRE); Between Knechtsvlakte and Sandveld (–BC), *Leipoldt 4036* (BOL); 18 km N of Vanrhynsdorp on N7 (–BC), *Le Roux 2045* (NBG); 30 km N of Vanrhynsdorp along N7 (–BC), *Van Zyl 3933* (NBG, PRE); 15 m E of Vanrhynsdorp at foot of Tigerberg (–DA), *Lewis 4828* (PRE); 6 km E of Vanrhynsdorp (–DA), *Hall 4299* (NBG, PRE); Near Urionskraal, Vanrhynsdorp, (–DB), *Van Zyl 4108* (NBG, PRE), *Barker 8574* (NBG); About half way up Mauwerskop, Vanrhynsdorp (–DB), *Snijman 1066* (NBG); Klawer (–DC), *Bond 1113* (NBG).

–3119 (Calvinia): 10 km from Nieuwoudtville on way to Loeriesfontein (–AC), *Van Zyl 4120* (NBG); About 50 M from Calvinia on way to Vanrhynsdorp (–AC), *Schmidt 625* (PRE).

7.52 Zygophyllum pubescens *Schinz* in Bulletin de l'Herbier Boissier 2, 8 : 631 (1908); Huysst.: 73 (1937); A.Schreib.: 96 (1963); A.Schreib. in Merxm. 17 (1966). TYPE - Namibia: Zwischen Hornkranz und Gansberg, *Fleck 710* (Z! holo.).

Zygophyllum rangei *Engl.*: 735 (1915), nom. nud.

Zygophyllum aureum *Engl.*: 735 (1915), nom. nud.

Misidentification: *Z. cuneifolium*, sensu Launert in Flora Zambesiaca: 125 (1963).

Erect or rounded, many-stemmed, woody shrub, reaching a height of 0.6 m and a diameter of 1.0 m, usually recorded as smaller due to heavy grazing. *Stems*: old stems nude, bark rough, dark gray; young stems green, usually covered with dense, short, retrorse hairs, rarely glabrous, elliptic in cross section and completely striate. *Leaves* opposite, sessile, subsessile or with short petioles, bifoliolate, usually glabrous, rarely pubescent; petiole when present 1–5 mm long; rachis apex triangular, membranous with setose margins, reflexed, caducous, 2 x 1 mm; leaflets articulate, green or khaki-green, widely to narrowly obovate or elliptic, 7–20(30) x (1)2–5 mm, apex rounded, mucronate when immature, lamina flat, base narrowed or obtuse; stipules triangular, membranous with setose or glabrous margins, reflexed, caducous, one on ventral side and one on dorsal side of stem, usually with notched apices, 2 x 1 mm. *Flowers* solitary, axillary. *Pedicel* 8—14 mm long. *Sepals* 5, ovate or obovate, some with membranous margins, 4.5–6.0 x 2.0–4.0 mm. *Petals* 5, obovate, apex obtuse, sometimes emarginate, base with a short claw, golden yellow, variously marked at base with red, M-shaped figures or unmarked, 10.0–12.0 x 4.5–6.0 mm. *Nectar disc* fleshy, papillate, regularly 10-angled. *Stamens* 10; filaments terete, 6—7.5 mm long; staminal scales 10, simple, oblong or narrowly obovate, apex obtuse, upper margins lacerate, 2.0–4.0 x 1.0–1.5 mm, ± 1/3 the length of the filament. *Ovary* oblong, 5-lobed; style terete; stigma simple. *Fruit* a drooping, oblong or subspheroid, 5-lobed, loculicidal capsule, lobes with a central ridge where splitting will occur, pubescent or glabrous, glossy-green or the central body often maroon-tinged, ridges green, 8–9 x 5–8 mm. *Seed* oblong, 1—2 locule, 4 x 2 mm, dark brown with a white aril, testa glossy, smooth, producing structured mucilage with long, spiral inclusions of a uniform width when wet (Figure 7.52.1).

Figure 7.52.1. *Z. pubescens, Van Zyl 3862.* A, flower with red markings; B, twig with a drooping, ridged fruit and leaves with short petioles; C, habit near Aus in Namibia.

Diagnostic characters and affinities

Z. pubescens is distinguished by its striate stems covered with dense, short and retrorse hairs (hence the specific epithet). The populations of this species which occur in the Windhoek area are exceptions being completely glabrous. With regard to stems, *Z. pubescens* resembles *Z. maculatum* and *Z. leptopetalum,* which have similar striate and hairy stems, an uncommon characteristic for southern African *Zygophyllum* species. These three species differ with regard to flower morphology. *Z. leptopetalum* has distinct white flowers with red veins and both *Z leptopetalum* and *Z. maculatum* have staminal scales bordered with papillae, which are lacking on the scales of *Z. pubescens*. With regard to leaf morphology Z. *pubescens* resembles *Z. leucocladum*. They have similar obovate or elliptic leaflets differing in size only, those of *Z. pubescens* slightly larger, and are the only southern African species of *Zygophyllum* with leaves that vary from a sessile to petiolate state.
In terms of vegetative morphology, *Z. pubesens* is a polymorphic species. In the Succulent Karoo on the SW side of Namibia, with its low winter rainfall and extreme summer aridity and temperatures, *Z. pubescens* is inclined to succulency and small leaves, an adaptation to the extreme climate. In the Savanna Biome around Kimberley and Vryburg, leaflets are narrower than elsewhere in its distribution range. In the Windhoek region this species is glabrous. Although the morphology of the leaves varies a lot, probably due to the variety of different biomes in which it occurs, there is a constancy in the morphology of flowers and fruits, justifying the status of a single species. Table 7.10 summarizes the characters of the species in § *Capensia* with petiolate leaves.

Distribution and ecology

Z. pubescens occurs in the southern half of Namibia with an outlyer population in the Kaokoveld. It is also found in the south and south-eastern part of Botswana and extends into the Northern Cape and North-West provinces of South Africa (Figure 7.52.2). In Namibia it occurs in vegetation classified as **Savanna Biome, Nama Karoo Biome** and **Succulent Karoo Biome** (Irish, 1994). The Savanna and Nama Karoo Biomes receive rain during summer whereas the Succulent Karoo Biome receives rain during winter. In South Africa *Z. pubescens* occurs in a vegetation

classified as **Savanna Biome**: Kalahari Plains Thorn Bushveld, Kalahari Mountain Bushveld and Kimberley Thorn Bushveld (Van Rooyen & Bredenkamp 1996). Rainfall ranges from 300—500 mm per year and falls in summer and autumn. Substrates are dolerite, occurring in the hills, and sandy to loamy sands, over calcrete. The vegetation is characterized by a grassy, ground layer with an upper layer of woody plants. Flowering occurs throughout the year with a peak in mid summer. Populations of *Z. pubescens* are described as abundant, fairly common or common. Grazing damage to *Z. pubescens* occurs and is also evident on herbarium specimens. Young plants or seedlings are rare. This species is probably palatable and is considered good grazing by farmers (personal communication). Because of its large distribution and the large size of populations, this species seems not to be threatened at present.

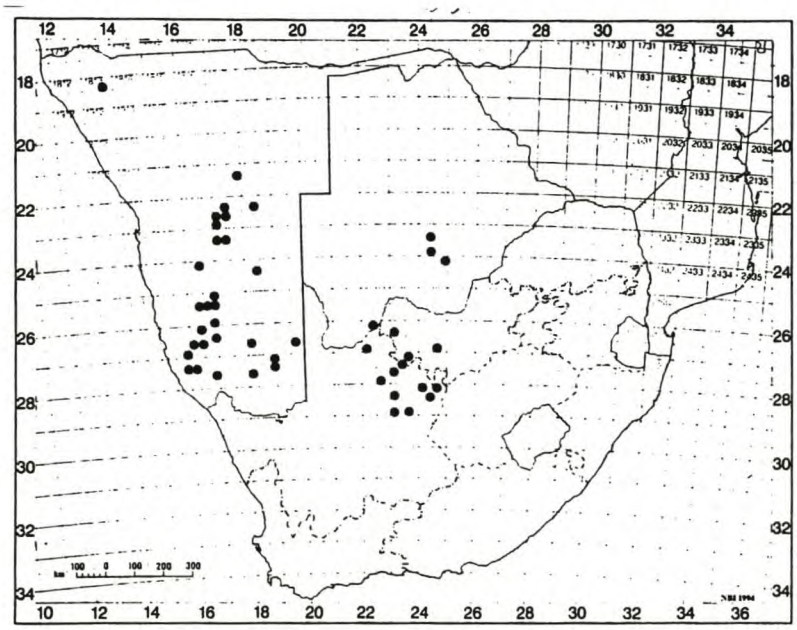


Figure 7.52.2. Geographical distribution of *Z. pubescens*.

Specimens examined

–1813 (Ohopoho): Kaokoveld - at Oruwanje (–BC), *Giess & Van der Walt 12798* (PRE, WIND).

–2117 (Otjusondu): On limestones at Otjosondu (–BD), *Walter 1428* (WIND).

–2217 (Windhoek): Voigtskirch, 35 M NE of Windhoek (–AD), *De Winter 2386* (PRE, WIND); Limestones at spring on Klein Windhoek (–CA), *Dinter 338* (B, SAM); *Bar s.n.* (TM 32906); 0.5 M from Windhoek on Gobabis road (–CA), *Van Vuuren 1180* (WIND); 18 M from Windhoek (–CA), *Liebenberg 4548* (WIND); Munisipal grounds at Windhoek (–CA), *Hanekom 267a* (WIND); Shale/quarts hill at Immental (–CA), *Von Koenen 528* (WIND); 12 M E of Windhoek (–CB), *Codd*

5808 (PRE, WIND); Finkelstein, E of Windhoek on road to Kapps farm (–CB), *Seydel 1743* (B, WIND); Voigtland: WIN 77 (–CB), *Volk 11307* (WIND); Windhoek, Bergland (–CB), *Seydel 4180* (B); Hohenau, waterfalls at Aloe koppie (–CB), *Walter 72* (WIND); Gochaganas on Auas Mountains (–CC), *Merxmüller & Giess 814* (PRE, WIND).

–2218 (Gobabis): Calcrete area on Eskadron - Witvlei (–AD), *Mason 2608* (PRE); Groot Witvlei, near Gobabis (–AD), *Gillman 20* (PRE, SAM).

–2317 (Rehoboth): Rehoboth - Aul (–AC), *Dinter 2237* (SAM); Limestone flats, 21 M N of Kalkrand on road to Rehoboth (–CC/CD), *De Winter 3534* (WIND).

–2324 (Kuchwe Pan): 28 km NW of entrance to Khutse Game Reserve via Salajwe (–AD), *Skarpe S-164* (PRE, UPS); Takatshwahe Pan (–CD), *Wild 5083* (GAB).

–2416 (Maltahohe): Top of mounntains in Bergzebrapark - Naukluft (–AB), *Van der Westhuysen 114* (WIND).

–2418 (Stampriet): Between Hofmeyer and Stamprietfontein (–AD), *Wilman 38334* (BOL, PRE).

–2424 (Dikgomo Di Kae): Limestones in Mone Valley near Letlaking (–BB), *Wild 4960* (BM, Botswana Nat Herb, PRE); *Barnes 226* (GAB); Limestones at Molepolole, SW of Letlhakeng (–BB), *Yatale 13* (Botswana Nat Herb); Calcrete hillside, 25 km before Letlhakane after Molepolole (–BB), *Barnes 342* (Botswana Nat Herb).

–2516 (Helmeringhausen): 20 km SW of Duwisib castle (–AD), *Van Zyl 3810* (NBG, WIND); Flats on Kleinfontein (–BB), *Dinter 3733* (SAM); Naudaus/Duwisib 76/84 (–BC), *Volk 12586* (WIND); *Volk 12704* (WIND); Maguaus - Kralwinkel (–BD), *Walter 2150* (WIND); 65 km from Helmeringhausen on road to Maltahohe (–BD), *Muller 36* (PRE, WIND); On farm Helmeringhausen in district Bethanie (–DD), *Kinges 2206* (PRE).

–2615 (Luderitz): Decomposed granite on Letterkuppe (–DD), *Hardy & Venter 4587* (PRE, WIND).

–2616 (Aus): Rocky flats at Tiras Mountains (–AB), *Merxmüller & Giess 2862* (PRE,WIND); S aspect of hillside on Wegkruip: BET 130 (–BD), *Giess 13402* (PRE, WIND); Decomposed granite on Municipal grounds at Aus (–CA), *Van Zyl 3862, 3880* (NBG); *De Winter & Hardy 7933* (PRE, WIND); *Dinter 3433* (BOL); *Giess, Volk & Bleissner 5242* (WIND); *Rogers 29575* (GRA); *Marcowitz 5* (WIND); Decomposed granite on Klein Aus, W of Aus (–CA), *Giess & Van Vuuren 743* (PRE, WIND); 3 km from turn off to Helmeringhausen along road to Aus (–CB), *Lang 20* (NBG); Saddle before homestead on Plateau: LU 38 (–CB), *Kraeusel/Wiss 2011* (WIND); *Owen-Smith 1151* (WIND).

–2618 (Keetmanshoop): Gellap Ost Experimental Station, Keetmanshoop (–CA), *Liebenberg 5173* (PRE, WIND).

–2619 (Aroab): Mullersrust, Aroab (–DA), *Barnard 29* (WIND).

–2622 (Tshabong): Kgalagadi pan floor, 6 km N of Tsabong (–AB), *Verlinden s.n.* (GAB s.n.); Riverbanks on Sunki (–CC), *Gubb 91-44* (PRE); Pan between dunes on Keesi (–CC), *Gubb 90-14* (PRE).

–2623 (Morokeng): Near Heuningvlei, Vryburg (–AC), *Rodin 3573* (BOL).

–2624 (Vryburg): Limestones on Tiger Kloof, Vryburg (–DC), *Brueckner 389* PRE); 64 M NW of Vryburg (–DC), *Leistner 589* (PRE).

–2715 (Bogenfels): NE slopes on Heioab, Sperrgebiet (–BD), *Oliver 10223* (NBG).

–2716 (Witputz): Bucholzbrun, 12 km W of Goageb (–AC), *Van Zyl 3855* (NBG); Arimas/Kolke, NE of Rosh Pinah (–DB), *Van Zyl 3906* (NBG); *Van Zyl 4400* (NBG, WIND); *Van Zyl 4416* (NBG, PRE).

–2718 (Grunau): On riverbank on Kochena: KEE 74 (–BB), *Giess & Muller 11916* (PRE); In ravine on Naruda Sud (–BD), *Pearson 7866* (BOL); Groendoorn, Klein Karas (–CA), *Örtendahl 373* (PRE).

–2722 (Olifantshoek): Sishen (–DC), *Collins 20* (PRE).

–2723 (Kuruman): Lime formations at Kuruman (–AD), *Pole-Evans 2071* (PRE); Hills at Kuruman (–AD), *Dedman s.n.* (STE 10044 in NBG); Limestones on Cardington, Kuruman (–BA), *Esterhuysen 2173* (BOL); Kathu Bush, Kuruman (–CA), *Sitwell 33* (PRE).

–2823 (Griekwastad): Kalkveld near Postmasburg (–AC), *Acocks & Hafström H1369* (PRE); *Acocks 1369* (BOL); On Kalkveld between Campbell and Griekwastad (–CC), *Acocks H1299* (PRE); Dolomite ridge, Campbell Aloe Patch (–DC), *MacDonald 77/78* (NBG); Surface limestone at Herbert, Campbell (–DC), *Brueckner 1072* (PRE).

–2824 (Kimberley): Koopmansfotein, Kimberley (–AA), *Toelken 1024* (PRE); River banks on Newlands, Barkly West (–AD), *Wilman 18* (PRE); Limestones on Newlands, Barkly West (–AD), *Ferrar 5680* (BOL), *Ferrar 77* (PRE); 10 M NE of Twee Rivieren, Kalahari Gemsbok National Park (–BA), *Leistner 1850* (PRE).

Unknown or no precise locality: Between Ombombo and Kaoko Otavi, *Barnard s.n.* (SAM 35589); Boon, *Range 95* (BOL, SAM); Naossonabis in district Gobabis, *Range 800* (BOL, SAM); On dolomite at Tierfontein, *Acocks & Hafström H1377* (PRE); Gross Namaland, *Schenk 95* (Z); Gross Namaland, *Schinz 1030* x 2 (Z).

7.53 **Zygophyllum leucocladum** *Schlechter & Diels in Schultze*, Aus Namaland und Kalahari, 705 (1907); Schlechter & Diels: 150 (1910); A.Schreib.: 84 (1963); A.Schreib in Merxm.: 16 (1966). Syntypes mentioned by Diels: Limestones at Chamis in Namibia, *Schultze 442* ; River bed at Koankip, *Schultze 463*. Schultze specimens in (B†), confirmed by Curator. No Schultze specimens traced in C, GB, H,KIEL, L, M, MB, UPS, W, Z. TYPE: Kleinfontein Nord: MAL 82, south of Maltahohe, *Van Zyl 3803* (NBG, neo., designated here, WIND).

Zygophyllum oocarpum *Huysst.*: 71 (1937); A.Schreib.: 84 (1963); A.Schreib. in Merxm.: 16 (1966); ex descr. TYPE - Namibia: Maltahohe, *Dinter 2083* n.v.

Zygophyllum sulcatum *Huysst.*: 72 (1937); A.Schreib.: 108 (1963); A.Schreib. in Merxm.: 19 (1966). TYPE - Namibia: Grabwater, Klein Karas, *Dinter 5049* (Z!, holo, B!, PRE!, X 3).

Although I could not find the type specimen of *Z. leucocladum* nor that of the synonym *Z. oocarpum,* their original descriptions are very clear so that there is no doubt that these two species are conspecific.

Erect or rounded, many-stemmed, woody shrublet, reaching a height of 0.4 m and a diameter of 0.6 m, usually excessively grazed and with smaller dimensions. *Stems*: old stems nude, bark rough, dark-gray; young stems prominently white or whitish, smooth, leaves regularly spaced and internodes clearly visible, flat on ventral side and with lateral ridges. *Leaves* opposite, sessile or subsessile, bifoliolate; rachis apex triangular, membranous, reflexed, caducous, 0.5 x 1.0 mm; petiole usually absent or only 0.5–1.5 mm long; leaflets articulate, green or glaucous, widely to narrowly obovate or elliptic, apex acute or obtuse, margins slightly recurved, base cuneate or obtuse, 7–12 x 2–5 mm; stipules triangular, membranous, reflexed, caducous, one on ventral side and one on dorsal side of stem, often with notched apices, semi-permanent, 1.0 x 0.5–1.0 mm. *Flowers* solitary or 2 together, axillary. *Pedicel 6*—12 mm long. *Sepals* 5, ovate or obovate, some with membranous margins, 3–4 x 1.5–2 mm. *Petals* 5, obovate, apex obtuse, emarginate, base with a short claw, pale or deep yellow, unmarked, fading to white with age, 7.0–9.0 x 3.0–3.5 mm. *Nectar disc* fleshy, papillate, regularly 10-angled. *Stamens* 10; filaments terete, 5—7 mm long; staminal scales 10, simple, oblong or narrowly obovate, apex obtuse, apical margin lacerate, 2.0–2.5 x 1 mm, ± 1/3 the length of the filament. *Ovary* ovoid, 5-lobed; style terete; stigma simple. *Fruit* a drooping, ovoid or oblong, 5-lobed, loculicidal capsule, lobes without ridges, exocarp thin and gradually disintegrating, seeds partially exposed, 5–13 x 4 mm. *Seed* oblong, 1—2 per locule, 3.5 x 2.0 mm, dark brown with a narrow, white aril, testa glossy, smooth, producing brown, structured mucilage with long spiral inclusions of a uniform width when wet (Figure 7.53.1).

Diagnostic characters and affinities

Z. leucocladum is distinguished by its prominently white stems (hence the specific epithet), by its bifoliolate, sessile or sub-sessile leaves with petioles at most 1.5 mm long, by its staminal scales with lacerate margins, but without any additional papillae

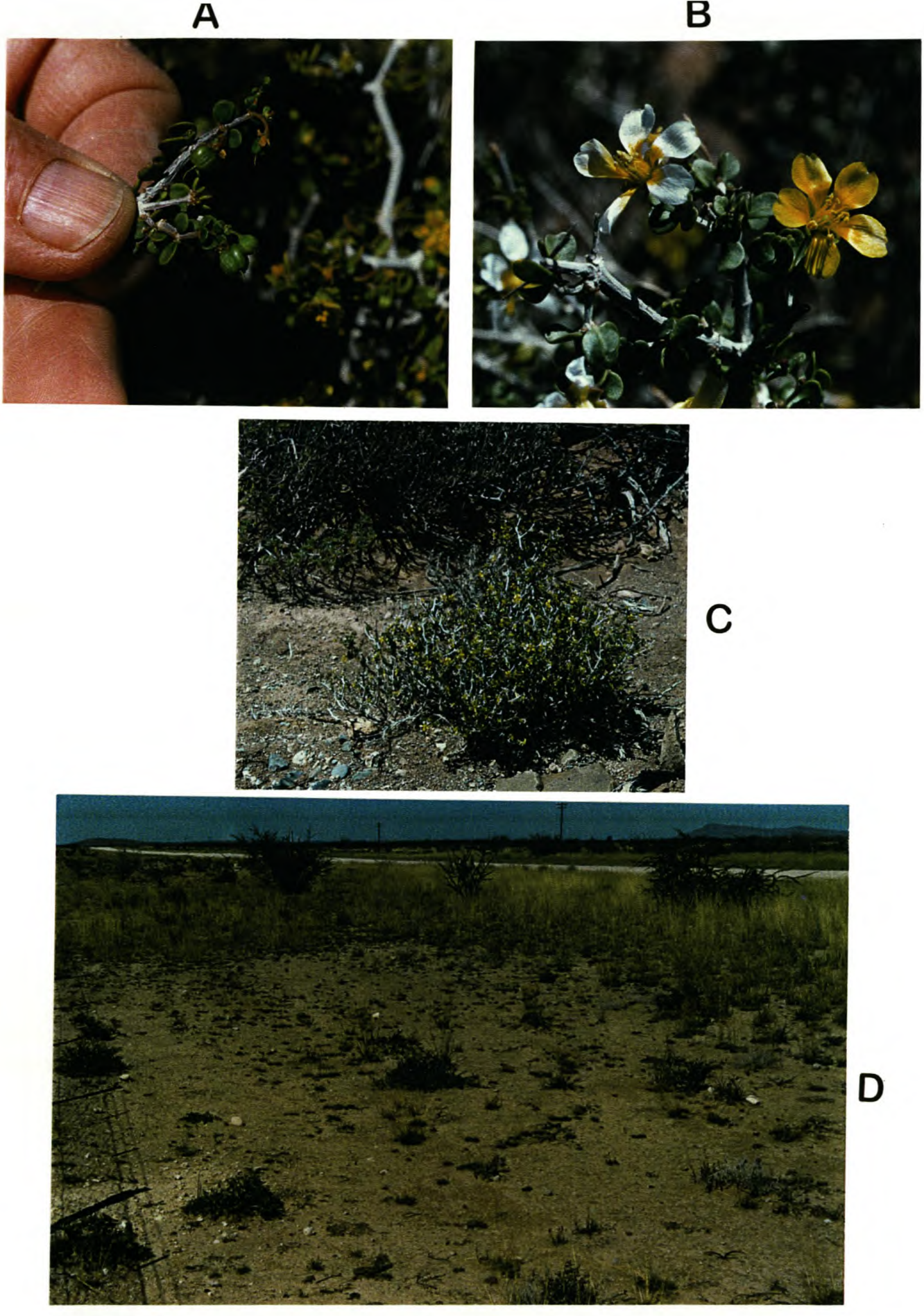


Figure 7.53.1. *Z. leucocladum, Van Zyl 4479*. A. leafy twig with immature, green fruits; B, leafy twig with flowers; C, grazed shrublet displaying prominently white stems; D, habitat near Helmeringhausen.

on its surface and by its ovoid or oblong, 5-lobed fruits, the lobes without ridges and with a thin exocarp that disintegrates, exposing the seeds. With regard to flower morphology *Z. leucocladum* is allied to those species without additional papillae on their staminal scales and which have a filament to scale ratio of 3 : 1, *Z. pubescens, Z. lichtensteinianum, Z. incrustatum, Z. debile and Z. maritimum.* With regard to fruit morphology *Z. leucocladum* resembles *Z. cretaceum*. Both species have similarly prominently white stems and small, 5-lobed fruits without ridges, with a thin, disintegrating exocarp, eventually exposing their seeds. This type of fruit is rare in *Zygophyllum* and found only in these two species. These two species differ with regard to their leaves and flowers. The staminal scales of *Z. cretaceum* have a dense border of curly papillae on its upper ventral surfaces and those of *Z. leucocladum* are without papillae. The leaves of *Z. cretaceum* always have petioles of 3–5 mm long and those of *Z. leucocladum* are 0.5–1.5 mm long. Table 7.10 summarizes the characters of the species in § *Capensia* with petiolate leaves.

Distribution and ecology

Z. leucocladum is found in southern Namibia, from Gobabis in the north to Witputz in the south and its range stretches from Helmeringhausen in the west to Mata Mata in the east (Figure 7.53.2). In Namibia it occurs in a vegetation classified as **Nama Karoo Biome** and **Savanna Biome** (Irish 1994). Both these biomes receive rain during summer. In South Africa it occurs in the **Savanna Biome**: Shrubby Kalahari Dune Bushveld (Van Rooyen & Bredenkamp 1996) with an annual rainfall of 200 mm per year during summer and autumn. The substrate is windblown sands over calcrete. This biome represents a typically shrubby vegetation with a well developed grass layer. Flowering occurs throughout the year. Populations of *Z. leucocladum* are locally frequent or dispersed over large areas. *Z. leptopetalum* is palatable and grazing damage occurs but the shrublets have woody bases from where many short branches sprout repeatedly. Grazing damage is also reflected on herbarium specimens. Young plants and seedlings are rare. Although *Z. leucocladum* has a fairly large distribution at present, its popularity with grazers may cause its distribution to diminish in future.

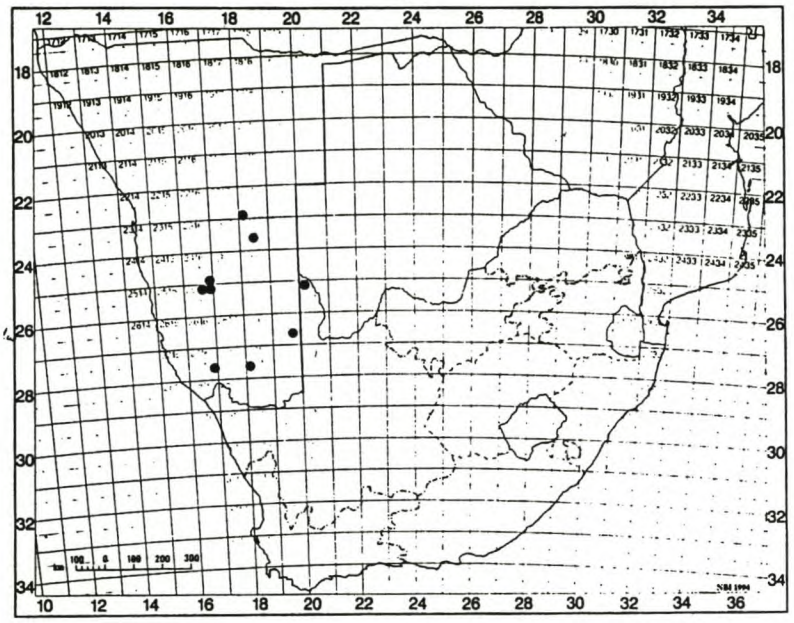


Figure 7.53.2. Geographical distribution of *Z. leucocladum*.

Specimens examined

–2218 (Gobabis): Kalkflache on Renette in district Windhoek (–CC), *Merxmüller & Giess 1061* (PRE, WIND).

–2318 (Leonardville): In river bed in shade of trees on Blumfelde: REH 95 (–CB), *Giess 5036* (PRE).

–2416 (Maltahohe): Brackflaeche on Christiana: MAL 44 (–DD), *Giess 8799* (WIND).

–2516 (Helmeringhausen): 48 km S of Maltahohe on Kleinfontein Nord: MAL 82 (–BA/BB), *Van Zyl 3803* (NBG,WIND); Mixed bushveld on Grootfontein: MAL 91 (–BB), *Giess 10705* (PRE, WIND); *Giess 10702* (WIND); 25 M SW of Maltahohe (–BB), *Acocks 15629* (PRE).

–2520 (Mata Mata): Duineveld on Loffiesdraai (–AA), *Van Rooyen 3644* (PRE); Limestones near pan Bayip in Kalahari Gemsbok National Park (–AA), *Van Rooyen 3719* (PRE).

–2619 (Aroap): Dune sands on Mullersrust, Aroab (–DA), *Barnard 29* (WIND).

–2716 (Witputz): Arimas 83, NE of Rosh Pinah (–DB), *Van Zyl 4479* (NBG); *Van Zyl 4417* (NBG, WIND); *Van Zyl 3906a* (NBG).

–2718 (Grunau): Kalkflache bei Grabwater (–CA), *Dinter 5049* (B, BOL, NBG, PRE, SAM, Z).

§ *Morgsana* (Huysst.) Van Zyl, stat nov.

Subsection *Morgsana* Huysst.: Morphologisch-Systematische Studien über die Gattung *Zygophyllum*.....: 64 (1937).

Type species: *Z. morgsana* L.

Diagnostic features

Young stems elliptic in cross section, not ridged or grooved
Leaves opposite, petiolate, bifoliolate
Flowers 4-merous; sepals 4, petals 4, stamens 8
Nectar disc fleshy, papillate, regularly 8-angled
Staminal scales 8, simple, with lacerated margins
Filament / scale ratio 2 : 1
Fruit a widely, 4-winged septifragal capsule

*Z. morsana*s has mechanism for releasing and dispersing seeds which differs from the loculicidal (subgenus *Zygophyllum*) or septicidal (subgenus *Agrophyllum*) methods. It is classified as septifragal (Spjut 1994), because the fruit opens **incompletely** along the dorsal or ventral sutures by a break in the partitions near the central axis, leaving a persistent columella after the valves have separated. In the case of *Z. morgsana* the endocarp separates completely from the central axis, but the exocarp remains intact resulting in incomplete splitting of the capsule. Most seeds are shed at this stage. The empty fruits of *Z. morgsana* remain attached long after flowering, become skeletonized, are shed eventually and are windblown. Kuun (1997) reports on the lack of crystals in the mesophyll of this species, further supporting its separation into a different section. Thus, because of its different dehiscing method, its lack of crystals in the mesophyll and the unique 4-merous nature of its flowers, *Z. morgsana* is incompatable with other species belonging to § *Alata*.

Table 7.11 Characters of subgenera *Agrophyllum* and *Zygophyllum,* and *Zygophyllum morgsana*

SUBGENUS ZYGOPHYLLUM	ZYGOPHYLLUM MORGSANA	SUBGENUS AGROPHYLLUM
fruit a loculicidal capsule	fruit septifragal	fruit a septicidal capssule
seeds oblong, not compressed, large, white aril present	**seed oblong, narrow white aril present**	seeds pyriform, compressed, funicula present
flowers large, 5-merous	flowers large, 4-merous	flowers small, 5-merous
petals yellow, usually marked at base	**petals yellow, marked at base**	petals usually white, rarely light yellow or orange, never marked at base
sepals not articulate, not succulent	**sepals not articulate, not succulent**	sepals articulate and usually succulent
nectar disc regularly angled	**nectar disc regularly angled**	nectar disc angled and lobed, lobes arranged in pairs
nectar disc always papillate, without raised or sunken areas	**nectar disc always papillate, without raised or sunken areas**	nectar disc smooth, sloping towards its periphery, with raised and sunken areas
young stems usually flat on ventral side and with lateral ridges, or elliptic, rhombic or round and striate	young stems elliptic	young stems usually grooved

From Table 7.11 it is clear that *Z. morgsana,* shows a greater affinity with characters of the subgenus *Zygophyllum* because of its different fruit and flower morphology. Ido not regard it as related to species in § *Alata* Huysst. *Z. morgsana* is now removed from § *Alata*, subgenus *Agrophyllum* and placed in monotypic § *Morgsana* (Huysst.) Van Zyl, subgenus *Zygophyllum.*

7.54 Zygophyllum morgsana *L.* Species plantarum: 385 (1753); L.: 373 (1767); Burm.f.: 12 (1768); Lam.: 442 (1786); Ait.: 61 (1789); Thunb.: 80 (1794); Willd.: 562 (1799); Pers.: 463 (1806); Thunb.: 544 (1823); DC.: 706 (1824); Don: 771

(1831); Eckl. & Zeyh.: 96 (1835); Sond.: 360 (1860); Huysst.: 64 (1937); Adamson & Salter: 535 (1950); A.Schreib.: 92 (1963); A.Schreib. in Merxm.: 17 (1966); Mason: 140 (1972); Gledhill: 145 (1981); Bond & Goldblatt: 437 (1984); Manning & Goldblatt: 160 (1996). TYPE - Habitat in Aethiopia: Without locality, collector unknown, (LINN 544.3!, holo.).

Zygophyllum capense *Lam.:* 443 (1786); Pers.: 463 (1806); DC.: 705 (1824). TYPE - Without locality, collector unknown, Collection Lamarck (P, holo!).

Z. brevipetiolatum Schltr. nom. nud. Brakdam, Hondeklipbaai, *Schlechter 11158* (Z!).

Erect, multi-stemmed, woody shrub, reaching a height and diameter of 1.5 m. *Stems*: old stems nude, grey, round in cross section; young stems green, smooth, elliptic in cross section, without a flat ventral area or lateral ridges, striate when dried. *Leaves* opposite, petiolate, bifoliolate; rachis apex narrowly triangular, membranous, reflexed; petiole 2—3 mm long; leaflets articulate, glossy green, asymmetrical, obovate or subrotund, apex rounded, base narrowed or obtuse, 15–30 x 12–19 mm; stipules membranous, widely triangular, sometimes with ciliate margins, reflexed, caducous, one on ventral and one on dorsal side of stems, 3–4 x 2–3 mm. *Flowers* usually two together, axillary. *Pedicel* 10–15 mm long. *Sepals* 4, obovate or ovate, some with membranous margins, margins sometimes ciliate, 5–8 x 3–5 mm. *Petals 4*, obovate or elliptic, apex rounded, often emarginate, base with a short claw, pale yellow with red or brown, M-shaped markings at base, 13–19 x 5–9 mm. *Nectar disc* fleshy, papillate, regularly 8-angled. *Stamens* 8; filaments terete, 8—9 mm long; staminal scales 8, simple, oblong or obovate, margins lacerate, 4.0–5.0 x 1.5–2.0 mm, ± ½ the length of the filament. *Ovary* oblong, 4-winged, apex retuse; style terete; stigma simple. *Fruit* a drooping, 4-winged, 26–40 x 26–40 mm in size, septifragal capsule, endocarp separating at ventral suture, exocarp remaining entire, with a slender central body and membranous, reticulate-veined, undulate, 10–15 mm wide wings, with a deep sinus at apex and base. *Seed* oblong, 1—4 per locule, 5.0–5.5 x 3.0 mm, dark brown with a narrow, white aril, testa smooth, glossy, producing structured mucilage with long spiral inclusions of a uniform width when wet (Figure 7.54.1).

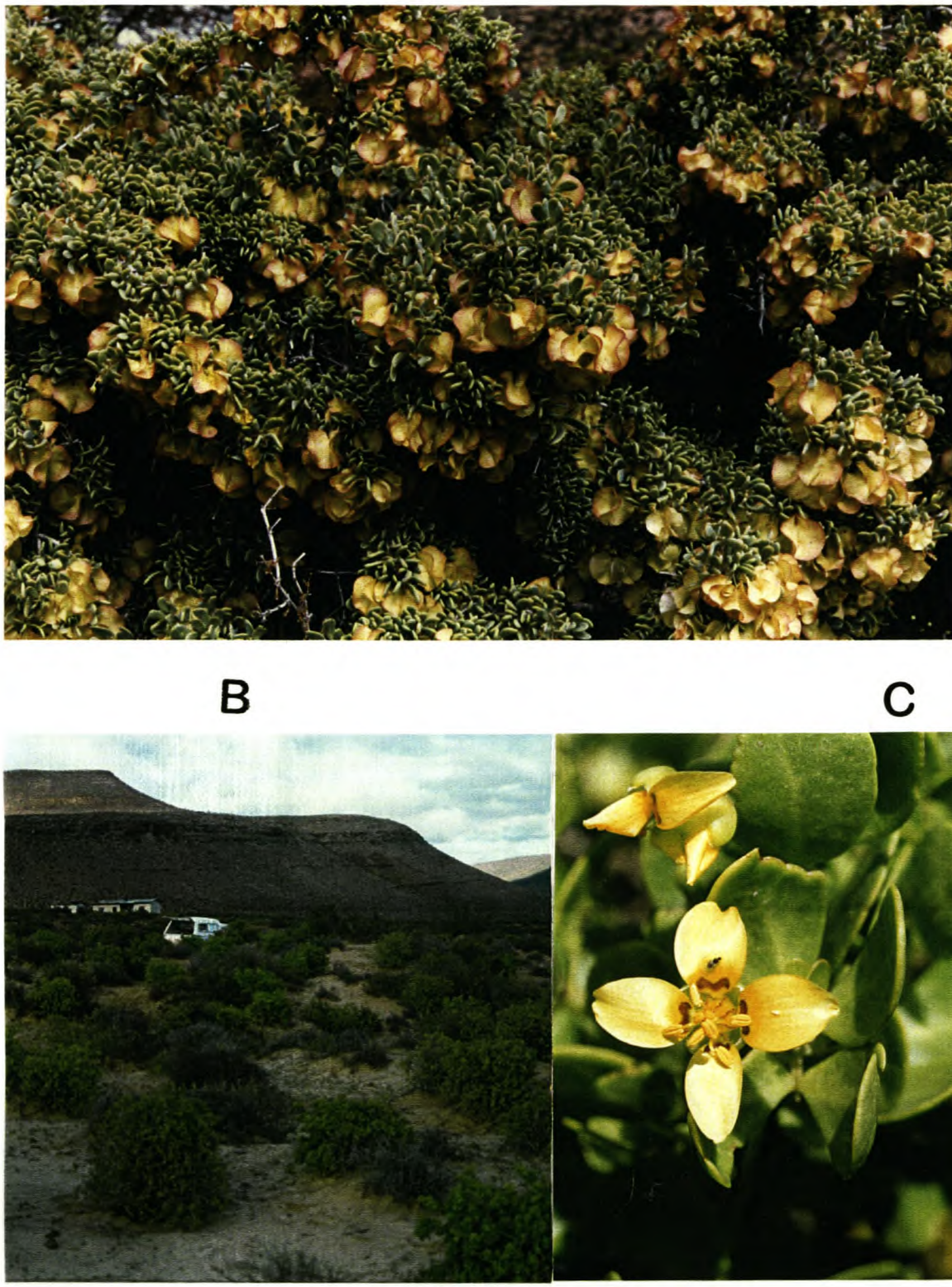


Figure 7.54.1. *Z. morgsana*. A, fruiting shrub, *Van Zyl 3930*; B, habit at the Doornrivier, Ceres Karoo, *Van Zyl 4215*; C, 4-merous flower, *Van Zyl 4378*.

Diagnostic characters

Z. morgsana is distinguished by its 4-merous flowers with 4 sepals, 4 petals and 8 stamens which is unique for the southern African species of *Zygophyllum,* all of which are otherwise 5-merous with 5 sepals, 5 petals and 10 stamens. The 4-merous floral state is a regular phenomenon amongst the Australian *Zygophyllum* species (Eichler 1981). It is also distinguished by its large fruits, 26–40 x 26–40 mm in size with four, 10—15 mm wide, reticulate-veined wings. Its fruits are the largest of the southern African *Zygophyllum* species and is classified as a septifragal fruit (Spjut 1994). The large wings do not serve as dispersal structures but as "shaking" organs (Rösch 1977) and most seeds are released (shaken out) before the fruits abscise.

With regard to vegetative morphology, *Z. morgsana* resembles *Z. foetidum*, *Z. leptopetalum*, *Z. macrocarpon* and *Z. cretaceum.* They all have similar petiolate, bifoliolate leaves with large, glossy green, asymmetrical, obovate leaflets which differ only in dimensions. The latter four species have the usual, 5-merous flowers and, with the exception of *Z. macrocarpon* which has large, winged, prismatic fruits, they have small 5-lobed fruits with or without ridges, never winged. When in a sterile state, *Z. morgsana* is distinguished from the others mentioned by its short petioles of 2—3 mm in length. Table 7.11 summarizes the characters of the subgenera *Zygophyllum* and *Agrophyllum* as well as *Zygophyllum morgsana.*

According to the medieval herbalist Rauwolff, the epithet *morgsana* reflects on the similarity between *Z. morgsana* and a Syrian *Zygophyllum* sp. with the common name "Morgsani" which was used as a vermifuge for children. The latter is currently known as *Z. fabago* L. (Mason 1972).

Distribution and habitat

Z. morgsana is widespread along the south and west coast of South Africa and extends into southern Namibia (Figure 7.54.2). In Namibia it is uncommon and occurs in a vegetation classified as **Desert Biome** and **Succulent Karoo Biome** (Irish 1994), both of which receive rain in winter. In South Africa *Z. morgsana* occurs from the Richtersveld in the north to the Cape Peninsula in the south, in the Little

Karoo and as far east as Port Elizabeth. It is found in vegetation classified as **Thicket Biome**: Dune Thicket, Zeric Succulent Thicket, Mesic Succulent Thicket and Spekboom Succulent Thicket (Lubke 1996); **Succulent Karoo Biome**: Strandveld Succulent Karoo, Upland and Lowland Succulent Karoo and Little Succulent Karoo (Hoffman 1996); **Fynbos Biome**: Central Mountain Renosterveld; South and South-west Coast Renosterveld; Mountain Fynbos, Laterite Fynbos, Limestone Fynbos and Sand Plain Fynbos (Rebelo 1996). Most of its distribution area receives rain during winter, but in the east of its range rain occurs throughout the year. It is a widespread species occurring in a variety of vegetations and on many different substrates which include shale, sandstone, limestones, dunes and granite. In spite of its large and varied distribution range, *Z. morgsana* shows little variation in its morphology.

The flowering period is from May to October and fruits are found until December. Populations of *Z. morgsana* are usually large and consist of many, scattered individuals. It is often the dominant species within the vegetation. Older shrubs usually bear less fruits and have smaller, bronzed leaves. Grazing damage is common and young plants and seedlings are infrequent. In spite of the grazing pressure, *Z. morgsana* remains a widespread, rather common species with large and many populations and it is not considered threatened at present.

Stock losses due to the grazing of *Z. morgsana* are reported by Eberhard (1977). This species is toxic to animals, producing diarrhoea with consequent loss of condition (Watt & Breyer-Brandwyk 1962).

Common names: leeubos(sie), skilpadbossie, skuimbossie, slymbossie, spekbossie, vetbos, vleisbos.

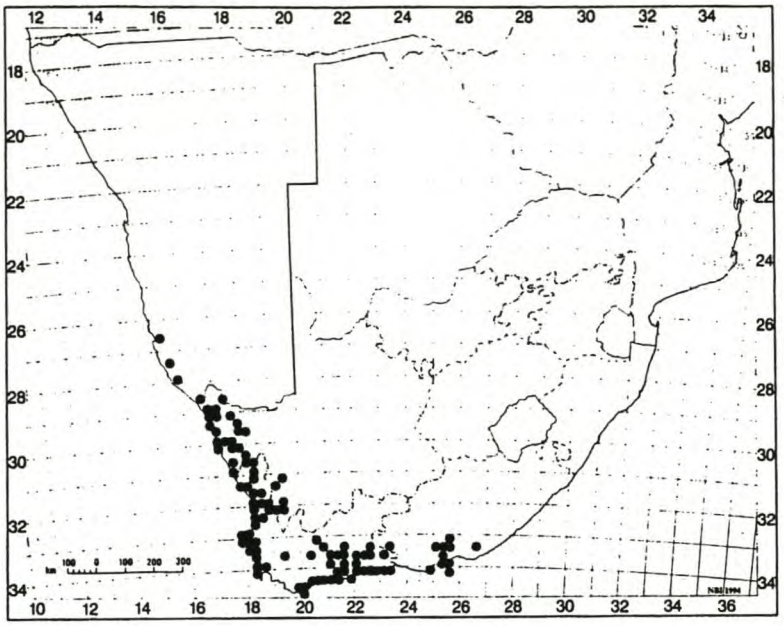


Figure 7.54.2. Geographical distribution of *Z. morgsana*.

Specimens examined

–2615 (Luderitz): Haalenberg (–CB), *Pillans 6009* (BOL).

–2715 (Bogenfels): Klinghardtsberge (–BC), *Dinter 4003* (PRE); *Dinter 3894* (B, BOL); Buchuberge (–DD), *Dinter 6519* (BOL, NBG).

–2816 (Oranjemund): 4 M S of Opperheimer Bridge (–DA), *Leistner 3470* (WIND); Holgatrivierbanke, S of Alexander Bay (–DD), *Van Zyl 4080* (NBG); 40 km from Port Nolloth on way to Alexander Bay (–DD), *Germishuizen 4726,* 4743 (PRE); Holgatrivier, 35 km from Port Nolloth (–DD), *Germishuizen 4809* (PRE);

–2817 (Vioolsdrif): 26 km from Eksteensfontein on way to Mount Stewart (–CB), *Germishuizen 4718* (PRE); Near Rooihoog, S of Eksteensfontein (–CC), *Van Zyl 4047* (NBG); Die Plate, S of Eksteensfontein (–CC), *Van Zyl 4046* (NBG, PRE); W of Eksteensfontein (–CC), *Van Zyl 4044* (NBG, PRE).

–2916 (Port Nolloth): 16 km N of Port Nolloth (–BB), *Koekemoer 893* (PRE); *Germishuizen 5325* (PRE); *Compton 20597* (NBG); Port Nolloth (–BD), *Galpin & Pearson 7589* (PRE, SAM); Littoral dunes at Oubeep, Wedge Point (–BD), *Le Roux & Ramsey 154* (NBG).

–2917 (Springbok): Karuchabpoort, 9 km S of Lekkersing (–AA), *Oliver, Tölken & Venter 792* (NBG, PRE); *Verdoorn 1822* (PRE); Anenouspas, W of Steinkopf (–BA), *Van Zyl 3925, 4034* (NBG); *Van Wyk 6196* (PRE); Rooidam se Koppe, at turn off to Eksteensfontein (–BA), *Van Zyl 4036* (BOL, NBG, PRE, WIND); Ratelpoort, 29 km N of Springbok along N7 (–BD), *Van Zyl 3822 (*NBG, PRE); 20 km S of Steinkopf along N7 (–BD), *Zietsman 706* (PRE); 2 km S of Kleinsee (–CA), *Hugo 2852* (NBG); Littoral zone on Brazil, Kleinsee (–CC), *Le Roux & Ramsey 239* (NBG, PRE); Rooivlei near Kleinsee (–CC), *Drijfhout 2845* (NBG); I km N of crossroads to Graafwater from Vaalkol (–CD), *Le Roux & Lloyd 505* (NBG); Springbok (–DB), *Van der Schijff 8154* (PRE); Eselsfontein, Spektakelpas (–DA), *Zietsman 897* (PRE); Sandhoogte, S of Nababeep (–DB), *Hugo 3040* (NBG); On Copperberg (–DB),

Pillans 6243 (BOL); 4 M W of Springbok (–DB), *Maguire 371* (BOL, NBG); Hester Malan Nature Reserve (–DB), *Rösch & Le Roux 255* (WIND); O'Kiep Copper Co. Golf course (–DB), *Rösch & Le Roux 62* (WIND); Wildeperdehoek Pass (–DC), *Ewes 2* (NBG); *Botha 2969* (PRE); Messelpad (–DC), *Compton 20662* (NBG); *Evrard 8882* (PRE); Oubees se sand, NW of Kamieskroon (–DC), *Van Zyl 4090* (NBG); N slopes of Rooiberg on E approach to Messelpad (–DC), *Hilton-Taylor 2137* (NBG).

–2918 (Gamoep): Plot 60 in Hester Malan Nature Reserve (–CA), *Rösch & Le Roux 1397* (PRE).

–3017 (Hondeklipbaai): Littoral dunes on Skulpfontein, Kleinsee (–AA), *Le Roux & Ramsey 252* (NBG); Toegabsrug, W van Kamieskroon (–BA), *Van Zyl 4094* (NBG); Arkoep, NE of Kamieskroon (–BB), *Van Zyl 3930* (NBG); Sandkraal, W van Garies (–DA), *Hilton-Taylor 1361* (NBG); Rocky hill near Garies (–DB), *Goldblatt 2263* (NBG); Dunes N of Groenrivier Mouth (–DC), *Le Roux & Ramsey 277* (NBG, PRE).

–3018 (Kamiesberg): Between Garies and Leliefontein (–AC), *Esterhuysen 4012* (BOL); Grootkop, Studor's Pass (–AC), *Van Zyl 4104* (NBG); Near Tweefontein, N of Bitterfontein (–CA), *Van Zyl 3753* (NBG); Zwart Doorn River, 10 M S of Garies (–CA), *Lewis 4826* (SAM); Past Uitspansberg, N of Bitterfontein (–CB), *Van Zyl 3752a* (NBG); Near Kwanous, N of Bitterfontein (–CD), *Van Zyl 3749* (NBG).

–3117 (Lepelfontein): Brakdam (–BD), *Schlechter 11158* (Z); Red sea dunes at Brand se Baai, NE of Nuwerus (–BD), *Van Zyl 3117* (BOL, NBG, PRE).

–3118 (Vanrhynsdorp): NW side of Kareeberge, Nuwerus (–AB), *Van Zyl 4006* (NBG); Nieuwerust (–AB), *Steyn 475* (NBG); Sandy beach at Olifantsrivier Mouth (–AC), *O'Callaghan 356* (NBG); *Le Roux & Ramsey 64* (NBG, PRE); Red sandy flats at Holrivier (–CB), *Van Zyl 3599* (NBG); Liebendal, 7 M N of Vredendal (–CB), *Hall 3639* (NBG); Vredendal, 0.7 km from the main road to Lossand Stasie (–CB), *Le Roux 2152* (NBG); Bobbejaansklip Nature Reserve, S van Doringbaai (–CD), *Van Zyl 4112, 4304* (NBG, PRE); Tentklip, S van Doringbaai (–CD), *Van Zyl 3992* (NBG); 8 km N of Vanrhynsdorp along N7 (–DA), *Le Roux 2019* (NBG); Vleikraal, E of Klawer (–DA), *Walters 109* (NBG); Mountains near Vanrhynsdorp (–DA), *Marloth 7581* (PRE); Foot of Nardousberge below Witbakenkop on old Clanwilliam-Vanrhynsdorp road (–DC), *Hilton-Taylor 1569* (NBG); Foot of Nardousberge, 10 km S of Doornrivier Bridge (–DC), *Van Zyl 3594, 3596* (NBG, PRE); Arid hills near Klawer and Olifantsrivier (–DC), *Lamb 3969* (SAM); Rocks on Gifberg (–DC), *Van Jaarsveld 6794* (NBG).

–3119 (Calvinia): Kareeboom, Calvinia - Loeriesfontein (–AB), *Burger & Louw 242, 250* (NBG, PRE); Meulsteenvlei near Nieuwoudtville (–AC), *Taylor 3927* (NBG); Langkuil next to Boomrivier, Botterkloof (–CD), *Metelerkamp 545* (BOL).

–3217 (Vredenburg): Dunes at Tietiesbaai (–DD), *Van Zyl 4196* (NBG).

–3218 (Clanwilliam): Nortier Experimental Farm (–AB), *Taylor 1606* (NBG); Near Hoekdam, W of Leipoldtville (–AB), *Van Zyl 4228* (NBG); Near Lamberts Bay (–AB), *Pole Evans 16* (PRE); Hills on N side of Verlorenvlei, Elandsbaai (–(AD), *Van Zyl 4121* (NBG); Behind first dunes on Westerwal, N of Dwarskersbos (–AD), *Van Zyl 4017* (NBG, PRE); Clanwilliam (–BB), *Schlechter 8013* (PRE); 9 M N of Clanwilliam (–BB), *Maguire 124* (NBG); Steenrug, Clanwilliam (–BB), *Le Roux 2502* (BOL); Road shoulders SE of Redelinghuys (–BC), *Van Zyl 4025* (NBG); 5 km W of Redelinghuys on road to Elandsbaai (–BC), *Van Zyl 4362* (NBG); Between Leipoldtville and Paleisheuwel (–BC), *Werderman &*

Oberdick 478 (PRE); Beach area of Dwarskersbos (–CB), *Van Zyl 3996* (NBG); NE corner of Rocher Pan Nature Reserve (–CB), *Le Roux & Van Rooyen 4* (NBG); Base of coastal dunes in Rocher Pan Nature Reserve (–CB), *Laidler 18* (NBG); Beach dunes in Rocher Pan Nature Reserve (–CB), *Le Roux & Ramsey 341* (NBG); Between Aurora and Velddrif (–CB/CC), *Rycroft 2131* (NBG); Berg River area, N of Velddrif (–CC), *O'Callaghan 1218* (NBG); 0.9 M from St Helena Bay towards Slipper Bay (–CC), *Marsh 187* (NBG).

–3219 (Wuppertal): Pakhuis, Clanwilliam (–AA), *Leipoldt 878* (BOL); N side of Doringrivier, Uitspanskkraal, Calvinia District (–AB), *Van Zyl 4219* (NBG); Gerustheid, next to Doringrivier, Calvinia district (–AB), *Van Zyl 4215* (NBG, PRE);

–3317 (Saldanha): Hill above Saldanha Bay (–BB), *Pamphlett 70* (NBG); Saldanha Bay (–BB), *Ecklon & Zeyher 753* (SAM).

–3318 (Cape Town): 5 km S of Langebaan on road to Darling (–AA), *Hugo 212* (NBG); 10.7 M from Hopefield to Vredenburg (–AA), *Marsh 180* (NBG); Geelbek (–AA), *Compton 19915* (NBG); S of Schrywershoek on Langebaan lagoon (–AA), *Marsh 1289* (NBG); *Boucher 5106* (NBG); Kersfontein, Hopefield (–AB), *Barker 4058* (NBG); Hopefield (–AB), *Herre s.n.* (STE 31756 in NBG); Erf in Yzerfontein (–AC), *Van Zyl 3605* (NBG); Hind dunes, N of Modderrivier Mouth (–AD), *O'Callaghan 1348* (NBG); N bank of Modderrivier, 200 m seaward of bridge (–AD), *O'Callaghan 1336* (NBG); Duynefontein, Koeberg (–CB), *Bösenberg & Rutherford 161*(NBG); Melkbosch (–CB*), Barker 5332* (NBG); *Dahlstrand 1053* (PRE); Sand dunes at Blaauwberg (–CB), *Stokoe s.n.* (SAM 66957); Groot Springfontein (–CB), *Wasserfall 247* (NBG); Clifton (–CD), *Page s.n.* (BOL 16501); Paarden Island (–CD), *Compton 13712* (NBG); Near Milnerton (–CD/DC), *Levyns 11493* (BOL); Near beach at Milnerton (–CD/DC), *Foley 5036* (SAM).

–3319 (Worcester): Worcester Karoo Garden (–CB), *Compton 22728* (NBG).

–3320 (Montagu): Whitehill ridge, Laingsburg (–BA), *Compton 13378, 14891* (NBG, PRE);Top of Suikerdrifkloof before the Old Tol (–BD), *Van Zyl 3709*, 3717 (NBG); Jakkalsfontein, Montagu (–CB), *Van Breda 1585* (PRE).

–3321 (Ladismith): Kloof on Gamka Mountain, Calitzdorp (–BC), *Boshoff P236* (NBG); E of dam wall in Gamkapoort Nature Reserve (–BC), *Laidler 690* (NBG, PRE); Huisrivier Pass, Ladismith (–BC), *Van Niekerk 534* (BOL); 1.9 km from dam in Noukloof Nature Reserve (–CA), *Laidler 65* (NBG); Steep slopes in Noukloof Nature Reserve (–CA), *Hilton-Taylor 908* (NBG); Hills near Vanwyksdorp (–CB), *Van Zinderen Bakker 308* (PRE); Gravel road to Matjiesvlei, N of Calitzdorp (–CC), *Van Zyl 3694* (NBG); Matjiesvlei, Ladismith (–DA), *Bayliss 256* (PRE); Pretoriuskraal, 0.5 km from turn off to Oude Wagendrift (–DC), *Laidler 508* (NBG).

–3322 (Oudshoorn): S entrance to Meiringspoort (–BC), *Van Zyl 3626* (NBG); Kliprivier, Oudshoorn (–CA), *Thorne s.n.* (SAM 51688); Oudshoorn (–CA), *Britten 38* (GRA); Roode Krantz, near Oudshoorn (–CA), *Bolus 11731* (PRE); Between Oudshoorn and De Rust (–CB), *Van Niekerk 483* (NBG); Karoo N of Robinson Pass (–CC), *Compton 23050* (NBG); Doornkraal, De Rust (–DA), *Dahlstrand 990* (GRA); *Dahlstrand 1443, 2115, 2264, 2349* (NBG, PRE).

–3323 (Willowmore): 20 km from Willowmore on Baviaanskloof road (–AD), *Van Wyk 381* (NBG); 5 km N of Uniondale on Barandas road (–CA), *Van Zyl 3641* (NBG); Vetvlei, Uniondale (–CA), *Markötter s.n.* (STE 25984 in NBG); *Markötter s.n.* (STE 8824 in NBG).

–3325 (Port Elizabeth): Between Roodewal and Bluekrantz (–AC/AD), *Bolus 1880* (BOL); Near Addo (–BA/BC), *Van Zyl 4180* (NBG); Rhinoceros camp, Addo (–BA/BC), *Botha 5799, 6591* (GRA); Smith, Klein & French factory land, Uitenhage (–CB), *Dahlstrand 1930* (NBG); Noorsveld on Renosterhoek, Uitenhage (–CD), *Hoffman 627* (GRA); Uitenhage (–CD), *Thode A2616* (PRE); Despatch (–CD/DC), *Holland 373* (PRE); Near Port Elizabeth (–DC*), Bayliss 2266* (NBG); Markmans Industrial area, Port Elizabeth (–DC), *Dahlstrand 3039* (GRA, NBG); Perseverance, Zwartkops River (–DC), *Long 683* (PRE).

–3326 (Grahamstown): Vaalvlei, Port Elizabeth (–BC), *Mogg 4745* (PRE).

–3418 (Simonstown): Llundudno (–AB), *Compton 8895* (NBG); *Willems 68* (NBG).

–3419 (Caledon): The Poort, between Elim and Bredasdorp (–DB), *Leighton 21082* (BOL).

–3420 (Bredasdorp): Dunes on De Hoop Nature Reserve (–AD), *Van der Merwe 145* (NBG, PRE); *Levyns 10696* (BOL); Dunes at Die Mond, De Hoop Nature Reserve (–AD), *Van Zyl 4285* (NBG); Koppies on De Hoop Nature Reserve (–AD), *Van der Merwe 1185* (PRE); *Barker 8737* (NBG); Windhoek Nature Reserve (–AD), *Van der Merwe 855* (PRE): Limestones near Potteberg (–BC), *Esterhuysen 23298* (BOL); Stony slopes at Breede River (–BD), *O'Callaghan 387* (NBG); Path above sea at Arniston (–CA), *Marsh 1450* (NBG, PRE); Sand at Cape Agulhas (–CC), *Van Zyl 4246* (NBG); Hind dunes W of Heuningnesrivier Mouth (–CC), *O'Callaghan 620* (NBG).

–3421 (Riversdale): Banks of Kaffirkuilsrivier, Stillbay (–AB), *Van Zinderen Bakker 310* (PRE); Riversdale (–AB), *Marloth 3537* (PRE); Karnemelksrivier, Riversdale (–AB), *Muir s.n.* (STE 10535 in NBG); Puntjie, N bank I km from mouth of Duiwenhoksrivier (–AC), *Boucher 2671* (NBG); Panorama circle 16, Stilbaai (–AD), *Bohnen 3863* (NBG, PRE); Near cemetery, Stilbaai (–AD), *Van Zyl 4281* (NBG); Stilbaai (–AD), *Strauss s.n.* (STE 25980 in NBG); *Jordaan s.n.* (STE 31754 in NBG); Elbertskraal, Stilbaai (–BA), *Muir 1643* (BOL); Coastal scrub at Bull Point (–BD), *Thompson 3726* (NBG); W side of Gouritz River mouth near Mosselbaai (–BD), *O'Callaghan 302* (NBG).

–3422 (Mosselbaai): Dunes near Groot Brakrivier mouth (–AA), *Parsons 388* (NBG); Mosselbaai (–AA), *Rogers 4242* (NBG); Blinderivier estuary (–AA), *Van Wyk, Fellingham & O'Callaghan 248* (NBG, PRE); Mosselbaai (–AA), *Rogers 4242* (GRA); 1.5 km from mouth of Gwain River (–AB), *Van Wyk, Fellingham & O'Callaghan 198* (NBG); Shoredunes at Wilderness (–BA), *Jacot Guillarmod 8268* (GRA); Camping area close to Swartvlei, Sedgefield (–BB), *Hugo 1990* (NBG, PRE); Milkwood forest in Goukamma Nature reserve (–BB), *Retief 430* (PRE); Groenvlei, Knysna (–BB), *Levyns 10282* (BOL); *Bayliss 1116* (PRE); On road to Platbank in Groenvlei area (–BB), *Van Zyl 3632* (NBG); Between Brenton and Belvedere (–BB), *Duthie 944, 1072* (NBG).

–3423 (Knysna): Buffelsbaai (–AA), *Keet 13721* (NBG); Near Walker Point, Buffelsbaai (–AA), *Levyns 7885* (BOL); Knysna Heads (–AA), *Michell s.n.* (BOL 16098); *Botha 2262* (PRE); *Breyer s.n.* (TM 23597); Near Beacon Island Hotel, Plettenbergbaai (–AB), *Van Zyl 3629* (NBG); Sea dunes, Plettenbergbaai (–AB), *Fourcade 1488, 6320* (BOL, NBG); Keurboomstrand, 8 M E of Plettenbergbaai (–AB), *Codd 3556* (PRE); Rocks on shore at Keurboomstrand (–AB), *Theron 1769* (PRE).

–3424 (Humansdorp): Drift over Kabeljouwsrivier, Humansdorp (–BB), *Galpin 3800* (PRE).
–3425 (Skoenmakerskop): Dunes at Cape Recife (–BA), *Olivier 2817* (GRA).
Unknown or no precise localities: On Lamberts Bay road, *Levyns 11688* (BOL); Clanwilliam, *Levyns 1289* (BOL); *Henrici 2112* (PRE); Calvinia, *Schmidt 636* (PRE); Matjiesrivier mouth, Knysna, *Gillett 2043* (NBG); Humansdorp, *Rogers 3030* (NBG); Brakdamm, *Schlechter 11158* (GRA); *Thunberg s.n.* (UPS); *Ecklon & Zeyher s.n.* , ad flumen Zwartkopsrivier (Uitenhage) (KIEL).

INSUFFICIENTLY KNOWN SPECIES

Zygophyllum dichotomum *Cham.* Linnaea 5 : 48 (1830). Colllected by Lichtenstein on the Orange River (B†). Described as a tall tree called Witgat, currently known as *Boscia albitrunca*, by the colonists.

Zygophyllum fasciculatum *Cham.* Linnaea 5 : 48 (1830). Described as at least a *Zygophyllum*, but position unclear.

Zygophyllum flexuosum *Eckl. & Zeyh.* var. **pruinosum** *Sond.*: 360 (1860). TYPE - Western Cape: In sandy places, between Olifant's River and Knakisberg, *Zeyher 276* (S!, K!). At the time of writing up this thesis, I was unable to come to a decision about this taxon. It is probably another new species closely related to *Z. spinosum* and not to *Z. flexuosum.* Although I have many sheets in my collection, I need to do some more field on this taxon.

Zygophyllum glaucum *Sond.* Fl. Cap 1 : 362 (1860). Type *Drège 3189* (Herb E. Mey and Sond.). Petiolate species, glaucose leaves - Namaqualand.

Zygophyllum horridum *Cham.* 46 (1830) No type or locality mentioned by Cham. According to the description this taxon belongs to § *Capensia*. According to Ind. Kew = *Z. microphyllum* L.f.

Zygophyllum horridum *Eckl. & Zeyh.* 96 (1835). TYPE: *Ecklon & Zeyher 772* (TCD! S!) - In my opinion this is probably **Z. chrysopteron** because of the character of the single young ovary on the TCD specimen and the distribution between Kochmanskloof en Swellendam 3320 CC/CD.

Zygophyllum macracanthum *Huysst. Morphologisch-systematische Studien über die Gattung* Zygophyllum...: 69 (1937) TYPE: In sand near Clanwilliam, *Schlechter 5054* (Z!), *Schlechter 8011* (Z!). This species of Van Huyssteen probably belongs to the *Zygophyllum flexuosum* var. *pruinosum* taxon.

Zygophyllum microphyllum *L.f.* Supplement 232 (1782). According to Sonder (1860), a species from Hantam, Bitterfontein and Onderste Roggeveld with shortly petiolate leaves. TYPE: Zeyher 277 (S!) but in all my wanderings I never came upon a similar specimen in the veld.

Zygophyllum sphaerocarpum *Schltr. ex Huysst.*, Morphologisch-systematische Studien.....: 73 (1937). Type Nieuwe Rust, nördlich von Vanrhynsdorp, 330 m, with flowers and young fruits, *Schlechter 11009* (B†). No specimens found in other Herbariums. According to the protologue this is a shortly petiolate species, belonging to § *Capensia*.

Zygophyllum trothai *Schlechter & Diels in Schultze*, 705 : (1907); Huysst.: 63 (1937); A.Schreib.: 106 (1963); A.Schreib. in Merxm.: 19 (1966); ex descr. TYPE - Namibia: Gross Namaland, Fläche um Chamis, (2616BB) *Schultze 412* (B†); not traced in the following Herbaria: B, C, GB, H, KIEL, L, M, MB, UPS, W, Z. According to the original description of this species, the length of the petiole could vary from 2—8 mm which makes its **inclusion in *Z. rigidum* doubtful,** because a diagnostic character of *Z. rigidum* is its very short petiole which should vary from 0.3—2 mm only.

Zygophyllum prostratum Thunb. Pr. Pl. Cap. 189 (1794) According to Index Kewensis this is *Seetzenia africana,* but I cannot comment on this because I failed to scrutinize *Seetzenia* in (UPS) while visiting the herbarium.

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INDEX OF NAMES AND SYNONYMS

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